POWER PLANT ENGINEERING

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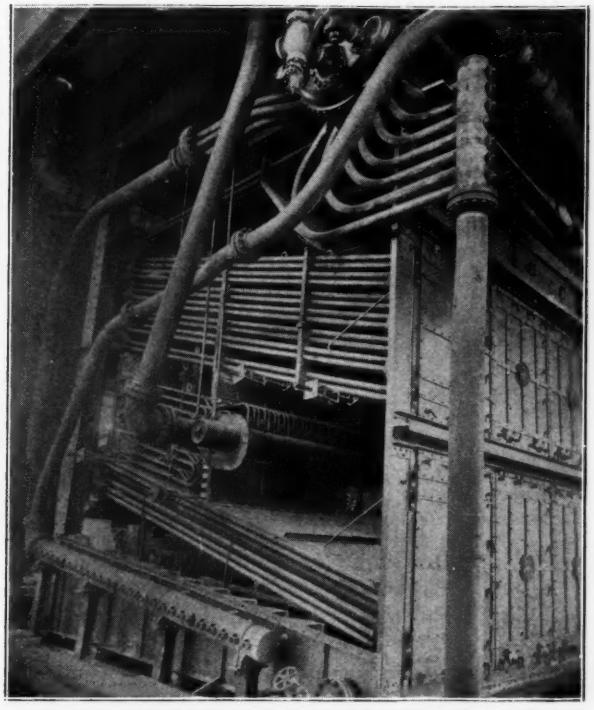


Just Like the Zodiac Man

DO YOU REMEMBER the Zodiac man in the old Farmer's Almanac that always hung on a nail in the kitchen when you were a boy? There he stood, hemmed in on all sides by Capricornus the goat, Pisces, Sagittarius, Leo and the other strange creations of the astrologer's craft. Strangest of all, a flap in his tummy was thrown back, exposing his internal machinery to all the winds of heaven—displaying to public gaze all the wonders of his complex arrangement of tubes, pipes and circulating devices.

When we first looked at the above picture, it reminded us instantly of the Zodiac man with his wide-open front. For here is one of the few pictures we have ever seen of a complete, modern water-tube boiler with all the piping, tubes, circulators, superheater tubes and gadgets in place. All that is necessary is to put on the casing and fire up.

Undoubtedly you will be interested in further details of this boiler and its operation, which are given on page 234 of this issue. The unit shown is one of two boilers at the new Kalamazoo Steam Plant of Consumers Power Co. put into operation about 1½ yr. ago. These boilers are fired with pulverized coal and Messrs. Mackenzie and Paddock discuss in a most interesting fashion some of the experiences of their company with this fuel at Kalamazoo.

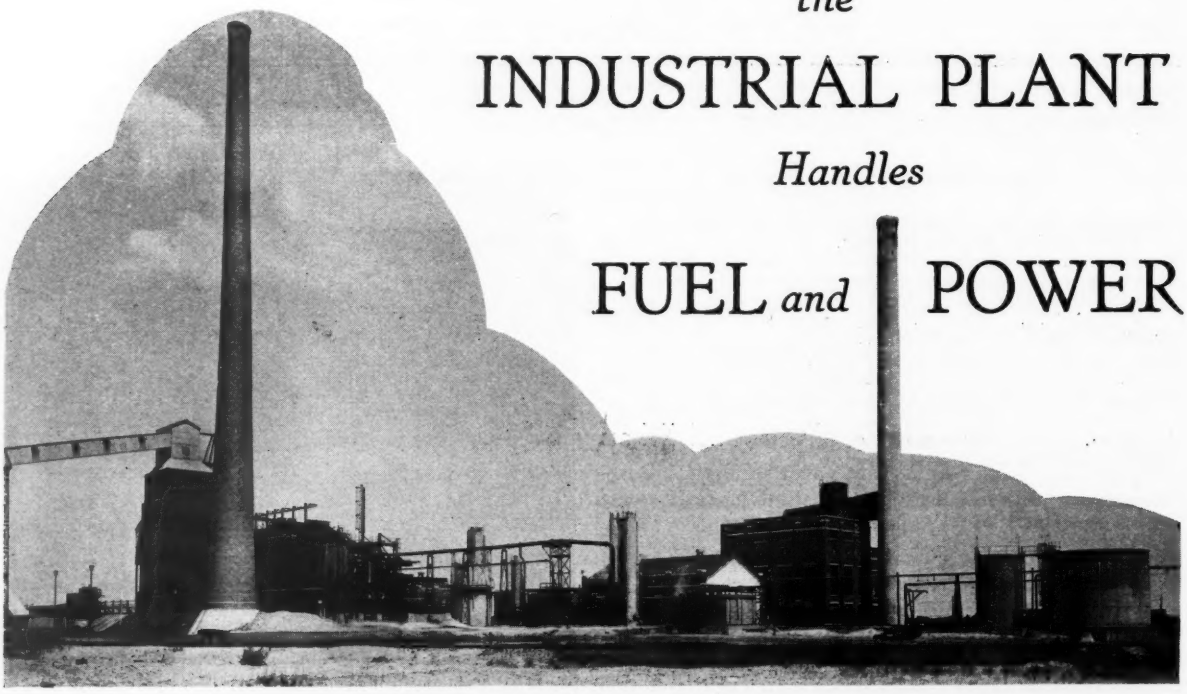
Commercial Success Depends Upon How

the

INDUSTRIAL PLANT

Handles

FUEL *and* POWER



How the North Shore Coke & Chemical Co. Handled Furnace Design and Electric Power Load to Anticipate Future Conditions and Meet Unusual Plant Demands. Furnace Design and Unusual Drag Scraper Coal Storage Outstanding Features

TO ACCOMPLISH SUCCESSFULLY his aim, the industrial power plant designer must not only develop a plant which in itself is complete but he must adapt his design and plant to meet the present and future demands placed upon it by the particular industry and the particular plant that it will serve. Appreciation of this factor is evident in the design of the new power plant of the North Shore Coke & Chemical Co. at Waukegan, Ill., designed by William A. Baehr Organization, Inc., of Chicago, Ill.

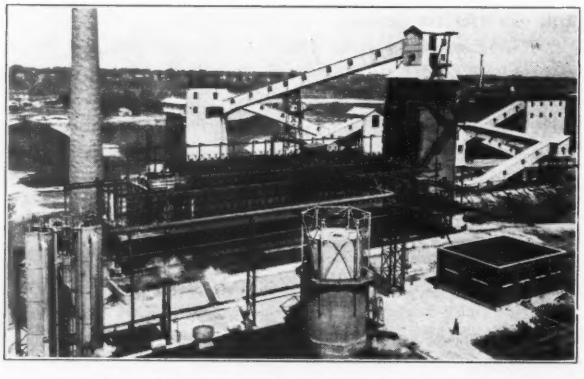


FIG. 1. COKE OVENS, CONVEYORS AND COAL STORAGE AS SEEN FROM THE POWER PLANT ROOF. COAL CONVEYORS ON THE LEFT, COKE CONVEYORS ON THE RIGHT

In this plant, two Heine 5110-sq. ft. four-drum boilers furnish 235 lb. gage, 150 deg. superheated steam to meet the heating and process steam requirements of the entire plant and to operate two Allis-Chalmers 750-kw. turbo generators, which in turn, carry the entire electric light and power load.

Ultimate Boiler Room Capacity, Eight Units

At present, the coke and chemical plant consists of one battery of 31, 9-t. coke ovens with a capacity of 3,000,000 cu. ft. of gas daily. Among its byproducts are ammonium sulphate, tar and pure sulphur, the latter being somewhat unusual in plants of this kind. Ultimately one more battery of 31 ovens and two batteries of 49 ovens will be added. This will require the completion of the boiler plant to its ultimate capacity of 8 boilers with, of course, a corresponding increase in electric generator capacity. The size of the future electrical units has not been determined as yet but the next will probably be a 1500-kw. machine.

Two major requirements are met by the power plant design. First it was desirable to design a furnace which would burn 100 per cent coke breeze at high boiler ratings and yet be adaptable to the common and available grades of coal if future developments were such as to make this desirable and second, it was necessary to handle heavy intermittent electrical loads on a small system, momentary rises of 200 and 250 per cent of the normal load being common.

Front Arch Can Be Shortened if Coal Is Used for Fuel

The first condition was successfully met by the furnace design, a cross section of which is shown in Fig. 1. As can be seen from the drawing, the suspended front arch is supported from two beams, giving an unusually long front arch, advisable for the proper combustion of breeze. This construction burns breeze successfully and yet gets away from the rear arch and constricted throat of the typical breeze furnace. If, in the future, industrial conditions make this feed too expensive for power plant use, the inside beam and nose of the arch

coal storage system. At present the gas plant uses about 450 t. of coal daily. This coal is received by boat from the coaling ports on Lake Erie and in order to provide sufficient fuel during the winter months, when navigation on Great Lakes is suspended and the harbor is closed by ice, a storage of some 100,000 t. is provided.

Coal storage and handling systems which will be described in more detail later, utilize a Mead Morrison electrically operated unloading tower and a Sauerman drag line storage system. Both of these pieces of equipment utilize motors while each pulls a load of 150 to 200 per cent of the normal electric load of the entire plant.

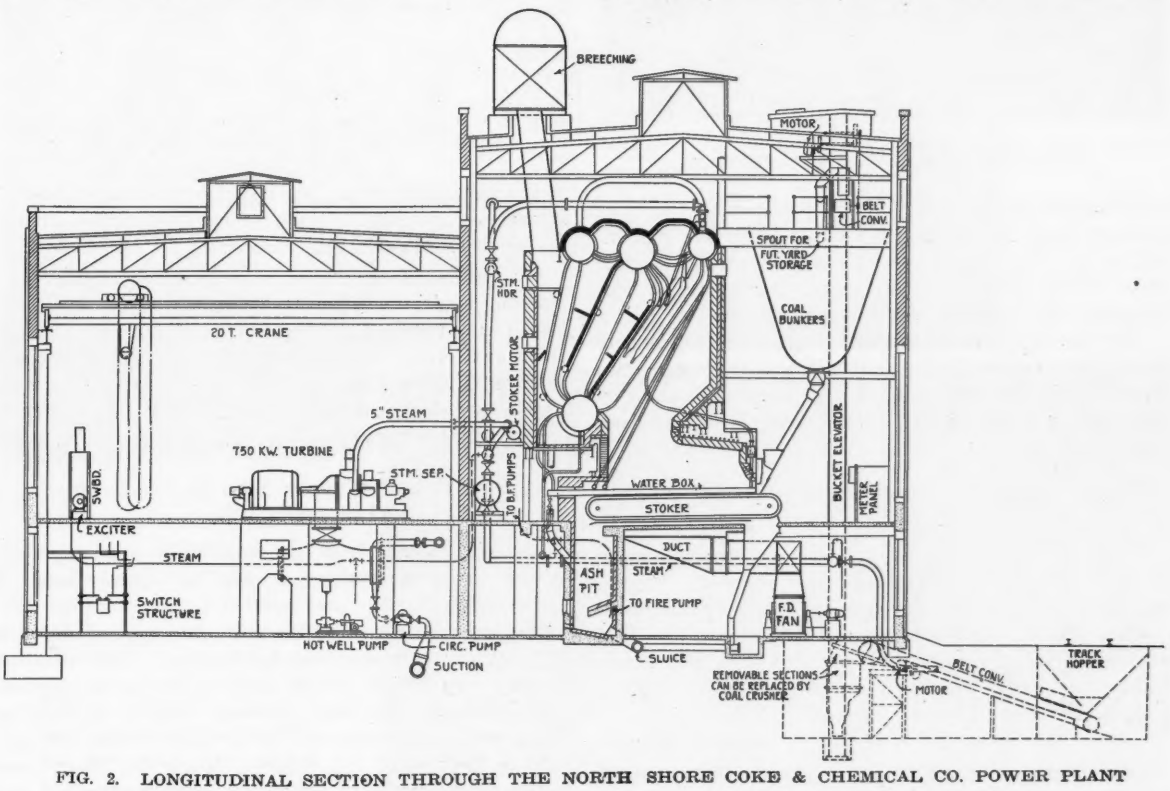


FIG. 2. LONGITUDINAL SECTION THROUGH THE NORTH SHORE COKE & CHEMICAL CO. POWER PLANT

can be removed easily and cheaply, giving an arch construction more adapted to the coals available.

At present, breeze is used exclusively except at times when the supply is not sufficient to meet the demands. In this case some coal is burned. Both boilers are fired by Coxe forced draft chain grate stokers driven by a constant speed motor through a Stephens-Adamson variable speed transmission. Automatic combustion control is maintained by a Carrick system.

Ratings of over 300 per cent as measured by a Bailey air flow steam flow meter, mounted on the instrument board shown in Fig. 4, are not uncommon and are carried with ease. Each boiler is equipped with an Elesco 384-sq. ft. superheater, 5-element Diamond soot-blowers and Copes feedwater regulators. Two Buffalo forced draft fans, one motor and one turbine driven, discharge into a common duct which supplies both boilers. An extension of this duct terminates in a plenum chamber above the arch to supply overfire air.

The second condition which demanded exceptional care in design came primarily from the demands of the

The large motor on the unloading tower is at 400 hp. and on the drag scraper 200 hp. It was, therefore, necessary to proportion the electric and steam auxiliary load such that the normal electric load would be large enough to avoid dangerous disturbances on the system when the large motors were in use and yet leave sufficient exhaust steam to supply the heating and process load.

Electric System Subject to High Momentary Overloads

This, of course, called for the utmost care in the selection of the prime mover, generator and governor equipment to handle such fluctuating loads. Normally the electric load runs between 200 and 250 kw. which is sufficient to steady the prime mover so that when the clamshell of the unloader digs in, pulling momentarily a load of between 400 and 500 hp., it is carried without any perceptible disturbance of the electric system.

In designing the plant, enough motor drives were used to give the necessary constant load, enough steam

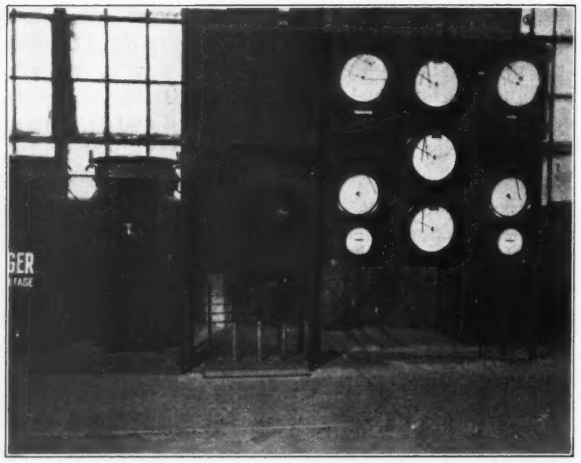


FIG. 3. INSTRUMENT PANEL AND TWO OF THE STATION TRANSFORMERS IN THE BOILER ROOM

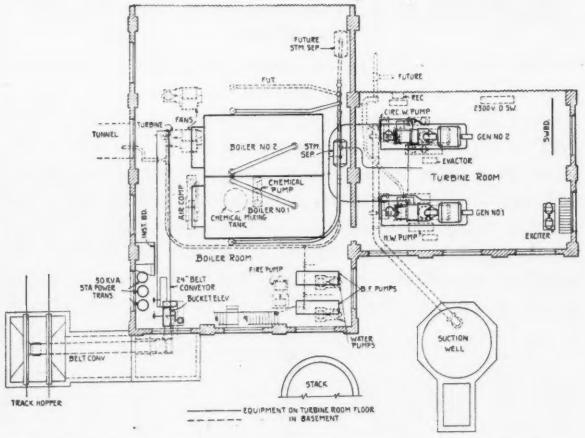


FIG. 5. PLAN OF THE OPERATING AND BASEMENT ROOM FLOORS OF THE POWER PLANT

auxiliaries were provided in the power house to give exhaust steam for feedwater heating while the remaining auxiliaries were provided with steam or electric drive, either for safety or to provide a measure of heat balance control during the different seasons.

For instance, each condenser has two condensate pumps, one motor driven and one turbine driven; two forced draft fans are installed, one motor and one turbine; and a steam driven exciter capable of handling both generators is provided.

Bleeder Turbine Supplies Steam to Low Pressure System in Winter

Each turbine, one of which is designed for automatic extraction and one which is not, is set over a 1260-sq. ft. condenser and in addition to the two 35-g.p.m. condensate pumps mentioned above each unit is provided with a 1300-g.p.m. motor driven circulating pump and a 7.4-c.f.m. two-stage steam jet vacuum pump with a combined inter and after condenser.

Condensate from the condenser is pumped through the evactor condensers and then directly to the storage heater. Boiler feedwater makeup is taken from the harbor and treated by a Cochrane hot process treater. In the winter, makeup is high because a large portion of the steam bled from the turbine is used in the heating system. Direct acting steam pumps located immediately under the feedwater heater are used for boiler feed.

Steam lines from the superheater of each boiler enter a steam header and drop to a separator from which the lines to the turbines and auxiliaries are taken. Turbine room auxiliaries are supplied from one line and boiler room auxiliaries from another. All steam driven auxiliaries are designed to use 235 lb. 150 deg. superheat steam and exhaust against a pressure of 20 lb. gage.

Low Pressure Steam Sold to Neighboring Industrial Plant

Exhaust steam from the auxiliaries and steam extracted from the turbine is used for heating some of the building and is also carried through a 6-in. low-pressure line 1000 ft. to the adjacent plant of Johnson Motor Co., where it is sold for heating. High pressure steam is also carried several hundred feet to the purification building. The high pressure steam is metered at the power plant, while the low-pressure steam sold outside is metered at the Johnson Motor Co. plant, temperature and pressure regulation being maintained and recorded by instruments at the power plant.

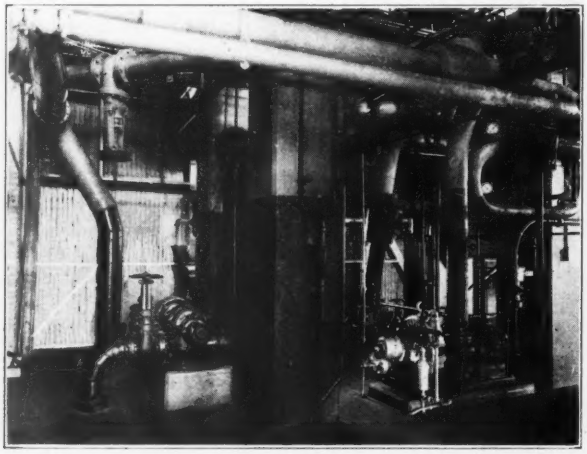


FIG. 4. CONDENSER AND AUXILIARIES. THE TURBINE DRIVEN HOTWELL PUMP IN CENTER FOREGROUND

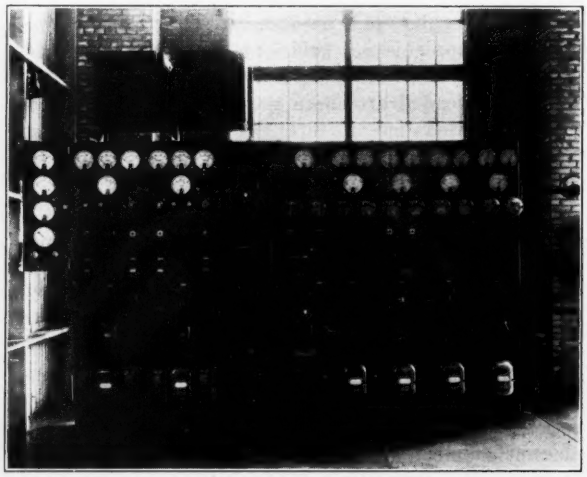


FIG. 6. AN EIGHT PANEL SWITCHBOARD IS PROVIDED TO HANDLE THE ELECTRICAL DISTRIBUTION

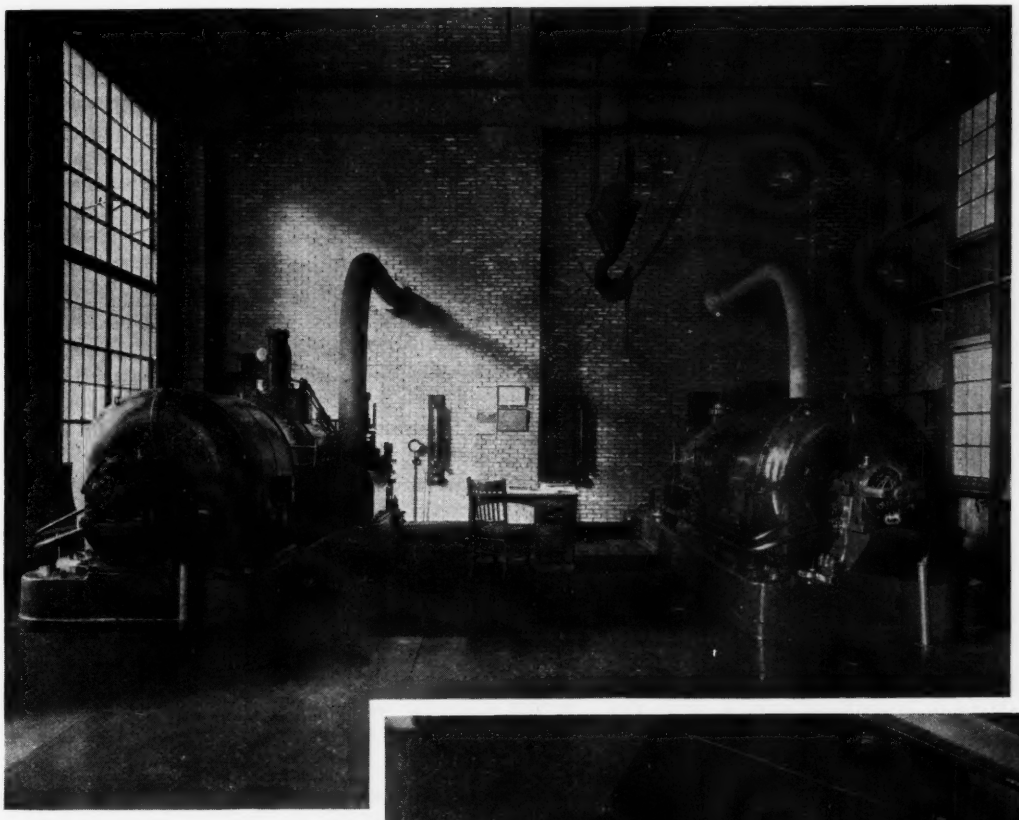


Fig. 7. (Above) Two 750-kw. turbines supply power for the entire plant which is independent of the public utility system.

Fig. 8. (Below) Forced draft chain grate stokers driven from the rear end burn 100 per cent coke breeze at 300 per cent of boiler rating.

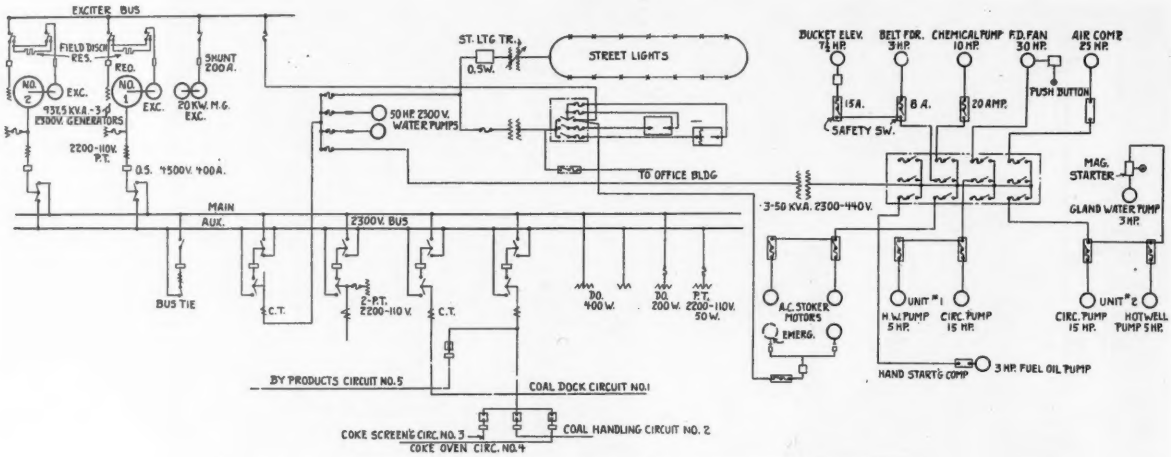


FIG. 9. SINGLE LINE DIAGRAM OF THE ELECTRICAL CIRCUITS

Circulating water for the condenser is taken from the suction well supplied with harbor water by a 24-in. C.I. pipe. This water is discharged into the lake just north of the power plant. The plant is not supplied with city water and general service water for the plant is taken from the same suction well by one of two motor driven 1000-g.p.m. centrifugal pumps. Fire protection is provided by a turbine driven 1000 g.p.m. fire pump, taking its supply from the same well through a separate suction line.

Condenser Water Recirculated in Winter to Raise Temperature of General Service Water

Boiler blowoff is piped to a blowoff tank near the harbor water suction well and later returned to the well in order to raise the temperature of the water in the

Principal Equipment in Power Plant of North Shore Coke & Chemical Co.

TURBINE ROOM

1 Allis-Chalmers Mfg. Co., 3600-r.p.m., 225-lb. pressure, 150 deg. superheat, automatic bleeder type steam turbine driving a 750-kw., 3-ph., 60-cycle, 2300-v. generator and a 9-kw., 125-v. direct connected exciter.

1 Allis-Chalmers Mfg. Co., 3600-r.p.m., 225-lb. pressure, 150 deg. superheat, condensing turbine driving the same type generator and exciter as above.

2 Allis-Chalmers Mfg. Co., 1260 sq. ft. surface condensers each with 642, No. 18 B.W.G., ¾ in. o.d. Muntz metal tubes 10 ft. long.

2 Allis-Chalmers Mfg. Co. 6 by 6-in., Type S-F, 1300-g.p.m., 30-ft. head circulating water pumps each driven by a 15-hp., 1750-r.p.m., 440-v. induction motor.

4 Allis-Chalmers Mfg. Co., 3 by 1½-in., Type C-S, 35 g.p.m., 115 ft. head hotwell pumps. Two driven by Allis-Chalmers 5-hp., 1750-r.p.m., 440-v. induction motors and two by

2 Terry Steam Turbine Co., 5-hp., Type Z1, 225-lb., 20 lb. Ga. back pressure, 1750-r.p.m. turbines.

2 Croll-Reynolds Co. 2 stg., evactors each with a capacity of 7.4 c.f.m. at 2.0 in. hg. abs. built with a combined inter and after cooler.

1 Westinghouse Elec. & Mfg. Co., 20-kw., 120-v., 1750-r.p.m., Style 83 compound wound exciter driven by

1 Dean Hill Pump Co., Wait, Type H00, 1750-r.p.m., 215-lb. gage, 100 deg. superheat steam pressure, 20-lb. gage exhaust, steam turbine.

1 American Steam Pump Co., size 1¼-in., Style HMR, centrifugal pump and receiver set for pumping gland water and draining the heating system. Driven by a float controlled, General Electric 3-hp., 440-v., induction motor.

1 Wm. W. Nugent & Co. Fig. 736, size 48 oil filter with a capacity of 160 g.p.h.

1 Viking Pump Co., ¾-in. rotary lubricating oil pump driven by a ½-hp. General Electric 1150-r.p.m. induction motor.

1 Westinghouse Elec. & Mfg. Co., 8-panel ebony asbestos switchboard with instruments, synchronizer and Type AE-3 voltage regulator.

1 Armington Engineering Co. 20-t. turbine room crane.

Oil circuit breakers..General Electric Co.
.....Westinghouse E. & M. Co.
Disconnects .....
...Electrical Engineers Equipment Co.
Mercury column..C. J. Tagliabue Mfg. Co.

BOILER ROOM

2 Combustion Engineering Corp., 5110-sq. ft., Heine, 4-drum boilers.

2 Superheater Co., Elesco 384-sq. ft. superheaters.

2 Combustion Engineering Corp., Coxe chain grate, forced draft stokers with an area of 150 sq. ft.

2 Buffalo Forge Co. size 4.75 forced draft fans with a capacity of 23,000 c.f.m.; 1 driven by

1 Fairbanks-Morse Co., 30-hp., Type-HV. 1800-r.p.m., 440-v. motor. The other driven by

1 Westinghouse Elec. & Mfg. Co., 26-hp., 1650-r.p.m., 225-lb. steam pressure 20 lb. back pressure steam turbine.

2 Dean Bros., 12 by 6 by 12 in., outside end packed, pot valve, direct acting boiler feed pumps.

1 Cochrane Corp. open, storage type, feedwater heater with capacity of 10,500 g.p.h.

1 Cochrane Corp. hot process feedwater treater. Chemical pumps and agitator driven by a 1750-r.p.m., 10-hp., 440-v. motor.

1 Stearns Conveyor Co. 30-in. belt feeder, driven at 45 ft. per min. by a Fairbanks-Morse, 3-hp., 900-r.p.m., 440-v. enclosed ventilated motor.

1 Stearns Conveyor Co. bucket elevator with 14 by 7-in. buckets spaced 24 in. on a 15-in., 5-ply belt with ⅛-in. cover. Driven at 240 ft. per min. by a Fairbanks-Morse, 7½-hp., 900-r.p.m., 440-v. enclosed ventilated motor.

1 Stearns Conveyor Co. 24-in. flat belt distributing conveyor driven at 170-ft. per min. from same motor that drives the elevator.

Bearings on conveyor rollers.....
.....Timken Roller Bearing Co.
Ash pit doors..Conveyors Corp. of America
Feedwater regulator .....
.....Northern Equipment Co.
Feed pump lubricator...Hills-McCanna Co.
Feed pump governors.....
.....The Fisher Governor Co.
Gas analyzer .....Hays Corp.
Indicating gages.....Federal Gauge Co.
.....U. S. Gauge Co.
.....Jas. P. Marsh Co.
Combustion control.....
.....Carrick Engineering Co.
Stoker speed control.....
.....Stephens-Adamson Mfg. Co.
Draft gages.....Ellison Draft Gage Co.
Flow meters.....Bailey Meter Co.
.....Republic Flow Meters Co.
Recording gages.....Foxboro Co.
Sootblowers..Diamond Power Specialty Co.
Blowoff valves.....Everlasting Valve Co.
Gage columns .....
....Reliance Safety Gauge Column Co.
Gage cocks.....Paul B. Huyette Co.
Boiler stop valves..Schutte & Koerting Co.
Boiler safety valves..The Ashton Valve Co.
Steam separator.....Wright-Austin Co.
Concrete stack.....Best Eng. Co.
Breeching and uptake.....
.....Waukegan Steam Boiler Works

MISCELLANEOUS

1 Allen & Billmyre Co., Tabco dust collecting unit driven by a Star 5-hp., 220-v., 3600-r.p.m. motor.

1 Chicago Pneumatic Tool Co., 9 by 8-in., Type NSB, single stage air compressor driven through a close belt drive by a Fairbanks-Morse, Type H, 25-hp., 1200-r.p.m., 440-v., induction motor.

2 Fairbanks, Morse & Co., 1000 g.p.m., 140-ft. head, Fig. 875 NE, centrifugal service water pumps driven by Type H, 50-hp., 1800-r.p.m., 2200-v. induction motors.

1 Dean Hill Pump Co., 6-in., 1-stg., 1000-g.p.m., centrifugal fire pump driven by a Wait, Type H1, 100-hp., 2400-r.p.m., 225-lb. abs. 150-deg. superheat, 25-lb. gage back pressure turbine.

Lockers.....All Steel Equip. Co.
Water heater...Lovekin Water Heater Co.
Wash room fountain.....
.....Bradley Washfountain Co.
Piping .....Crane Co.
Valves and fittings.....Crane Co.
Traps.....Armstrong Machine Wks.
Metal window sash.....Truscon Steel Co.
Steel grating.....Arrowhead Iron Wks.
Motor starters and switches.....
.....Fairbanks, Morse & Co.
.....General Electric Co.
.....Square D Co.
Wall heaters.....Modine Mfg. Co.

winter months. It is planned to pipe the condenser circulating water so that it may be recirculated to the suction well in cold weather. Ash are sluiced through a cast-iron pipe north of the plant and used for fill.

The building itself is of brick construction with metal window sash and a temporary wall in the north end to allow expansion. Stairways and gratings are provided in the boiler room to give access to all parts of the equipment and all valves. In the turbine room, the floor between the units is steel grating which is removable so as to allow replacement or handling of the condenser auxiliary by means of the turbine room crane.

In the basement, a washroom with steel lockers, an automatic gas fired water heater, wash fountain and showers are provided. Compressed air for general service is provided by a Chicago Pneumatic 9 by 8-in. single stage motor driven compressor. A Tabco vacuum cleaner unit is also provided.

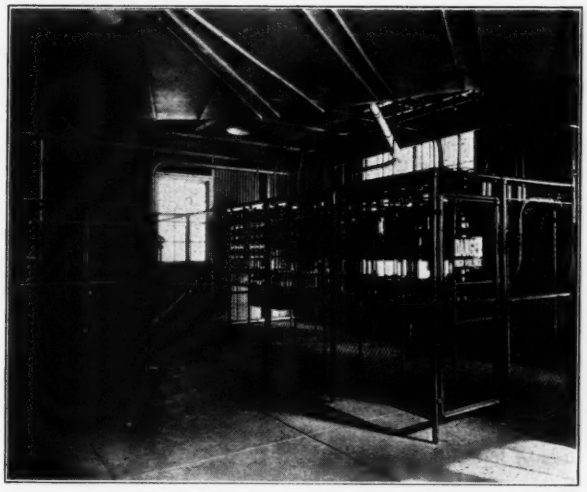


FIG. 10. SWITCHES AND DISCONNECTS ARE LOCATED IN AN ENCLOSURE ON THE BASEMENT LEVEL

Large Coal Storage Utilizes Drag Scraper

Although the coal storage is not a part of the power plant, it is of interest to the power plant designer of large industrial plants or central station, because of the economical and simple solution of the storage problem.

After unloading from the boat, the coal is stored in an area roughly 425 ft. wide by 1400 ft. long as shown in Fig. 2, by a Sauerman 7-yd. bucket, which carries 5 t. at a time. Two self propelled self supporting tail towers are used so that the scraper can be changed easily and quickly from one storage to another, and so that it can work in either direction along any described line of operation to store and reclaim coal any place on the entire rectangular shaped storage area. At an average haul of 200 ft., the scraper has a capacity of 260 t. per hr.

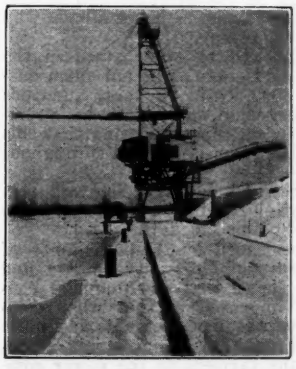
Beginning at the hopper and extending around the entire area is an 18-ft. gage track which carries both the tail towers and the self propelled unloading tower. By means of the tower, the coal is piled in long narrow piles about 40 ft. high just outside of and parallel to the track. The scraper takes the coal from these piles and stores it about 30 ft. deep.

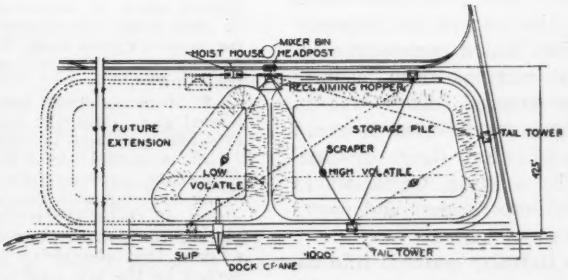
Provision for emergency shipment of coal by rail has been made by providing a track hopper near the headpost of the drag scraper. Coal required for immediate use will then go directly to the plant and the remainder will be spouted from the tower in which the hoist operator stands, into the storage area to be stocked out by the scraper. The cost of this scraper installation was approximately $44,000 or about 1/10 the cost of stocking and reclaiming bridges for the same service.

Fuel handling in the power plant itself is simple. Coke breeze, moved from the coke plant in cars is dumped into a track hopper, delivered by a short inclined belt feeder to a bucket elevator and distributed to the 90-t. overhead bunker by a flat belt conveyor. It is then spouted to the stoker hoppers by gravity.

Power Plant Has Been Designed to Burn Coal Later if Necessary

Provision for burning coal has been made, by providing space for a crusher between the feeder and elevator and designing the discharge end of the elevator so that a spout can be added later to stock coal in the area south of the plant. This change in fuel would be necessary only if the price of coke breeze increases to a point when it is no longer advisable to burn it under boilers. A low grade coal, different from that used in the coke plant, would be substituted.





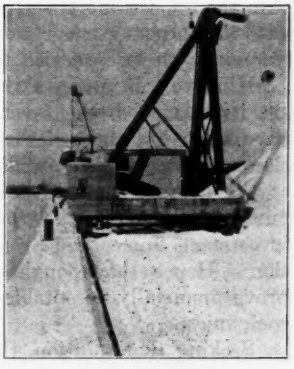
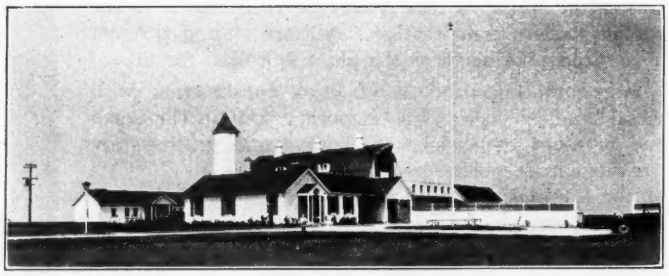


FIG. 11. (LEFT) UNLOADING TOWER. FIG. 12. (CENTER) DIAGRAM OF COAL STORAGE. DOTTED AND SOLID LINES SHOW THREE OF THE MANY POSSIBLE CHANGES IN THE LINE OF OPERATION. FIG. 13. (RIGHT) ONE OF THE TWO SELF-PROPELLING DRAG LINE TAIL TOWERS

Farm Relief



ELECTRIC POWER SUPPLY PROVIDES CONVENIENCES, REDUCES LABOR AND ADDS TO PROFITS.

BY CHARLES F. STUART*

IF THE BUSINESS MEN who manage the electric light and power companies of this country were actuated solely and only by a desire to keep the dollars rolling in, the electrification of the American farm would have progressed much less than it has during the last five years.

It is granted that the executives of the power companies throughout the nation are good business men. They have to be to keep the electric business on its present sound financial basis. It is evident, however, that they possess, in addition to business ability, a keen sense of the obligation to serve wherever service is possible, a little bit of the spirit of adventure and that they get a bit of a thrill out of the opportunity to explore pioneer fields.

RURAL DEVELOPMENT WAS PIONEERING

This becomes apparent as the recent history of electrifying the farm unfolds itself. Just a few years ago, the outlook for extending electric light and power company service to the farm was about as gloomy, pessimistic and discouraging a vista as one could imagine. Of course, many companies had tried it out. In fact, practically all the companies had taken on one or more farm lines but a check-up throughout the nation revealed that, with the exception of some of the Pacific Coast areas where power for irrigation purposes supplied an acceptable rural load, hardly a farm line in the country was standing on its own feet financially.

Certainly it was not the possibility of financial gain which actuated the electric companies in seeking ways and means to make their service available to the farmers. There must have been some of the spirit of adventure, there must have been a keen sense of the obligation to serve and there must have been that thrill which comes with the opportunity to explore in pioneer fields, otherwise the industry never would have tackled the job of extending electric service to agriculture.

Mind you, in undertaking to solve this problem and get its service to the farms, the men of the industry have never lost sight of the fact that a successful solution of this problem prohibits carrying farm business at a continuous loss to the companies. They kept in mind at all times that farm lines must become a sound investment immediately or soon after their construction. Hence they sought the solution which would prove financially acceptable to both farmers and power companies.

Seeking that solution, the industry entered into co-operative investigations with farm organizations, agricultural colleges, manufacturers, governmental bodies and other interested parties as co-workers.

RESULTS HAVE BEEN ENCOURAGING

Considering the discouraging outlook in 1923 and 1924, when these co-operative experiments got under way, the results have exceeded the fondest hopes of the investigators. Here are some of the things which have been accomplished since the first experimental rural line was put into operation at Red Wing, Minnesota, December 24, 1923:

1. Service has been extended to more additional farms than during all previous years combined.
2. Something like two hundred uses for electricity in various types of farming throughout the nation have been developed and accurate records obtained.
3. On one experimental line alone, that at Ripon, Wis., definite data concerning more than one hundred and fifty different applications has been obtained, tabulated, and made available to all interested parties.
4. The National Committee on the Relation of Electricity to Agriculture, Garland Building, Chicago, Ill., collected all experimental data available as of January 1, 1928, and published it in one volume entitled Electricity on the Farm.
5. Rural electric service departments manned by individuals thoroughly familiar with and up-to-date on the modern day applications of electricity to agriculture have been inaugurated by numerous electric light and power companies so that today certainly more than five hundred individuals, who specialize in this particular work, are on the payroll of the various electric light and power companies.
6. Due to all these activities, the farmer, instead of confining his use of electricity to a few lights and going to bed with the chickens, as was true a few years ago, now employs this silent servant liberally, not only to supply his family with the conveniences of electric service but to cut his labor costs and increase production. This amounts to the electrification of the farm plant.
7. While the average consumption of electricity on the farm five years ago was in the neighborhood of 300 kw-hr. a year, the modern day farmer is using all the way from 1200 up to 25,000 kw-hr. a year.
8. In answer to a recent call to every state in the union to supply names and addresses of actual farm customers using in excess of 3000 kw-hr. a year, hundreds of such names have been turned in, often with the promise to send plenty more if needed, thus indicating that this development of the load on the farm is general throughout the country.
9. Much evidence has been made available that this liberal and intelligent use of electricity on the farm is an excellent business investment for the farmer.
10. A report about to be issued by the University of Minnesota covering four years of electricity on five Red Wing experimental farms, shows that the financial condition of these farms had improved so that when comparing the fourth year with the first year it was quite evident that electricity had paid its own cost, as represented by the bill paid by the farmers to the power company; had paid interest and depreciation on the investment in electric equipment; also interest and depreciation on other equipment for which electricity was indirectly re-

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sponsible but which is more properly chargeable to a higher standard of living; and had left the farmer with a nice little profit over and above all this.

11. The farmer who complained because of the necessity of paying $4 or $5 a month for electricity, which he used almost entirely for lighting purposes, is rapidly being replaced by farmers paying upwards of $15 a month for ten, twenty or more times the service and who employ this considerable amount of energy to their own financial advantage as well as for the convenience of the entire farm family.

Let us analyze some of these statements: On January 21, 1924, reports from many states indicated that, at that time, only about 200,000 farms in the United States were receiving service from electric light and power companies. As Chairman of the Rural Electric Service Committee of the National Electric Light Association, I recently requested all states to report the number of farms served. All the answers to this request are not in as yet but I have reports from 26 of the 48 states showing a total of 339,456 farms and there is every reason to believe that the completed count will carry the figures over the 500,000 mark.

Here are the states which have reported:

New Jersey	11,800
New York	42,000
Pennsylvania	25,630
Kentucky, Ohio, West Virginia	42,111
Illinois	13,284
Indiana	15,163
Michigan	12,500
Wisconsin	18,227
Virginia	5,000
Minnesota	10,500
North Dakota	1,000
South Dakota	2,500
Idaho	7,216
Montana	663
Oregon	11,428
Utah	10,114
Washington	34,443
Arizona	900
California	62,720
Nevada	1,200
Colorado	3,872
New Mexico	225
Wyoming	410
Alabama	6,550
	339,456

Rural Service Departments

Accuracy of the statements regarding subjects Nos. 2, 3 and 4 above are obvious. Experimental investigations were launched in 24 states each dealing with the types of agriculture peculiar to those states. The investigators put electricity to work at every conceivable task on the farms and the National Committee on the Relation of Electricity to Agriculture made it its job to act as a clearing house for all this data.

The creation of rural electric service departments by power companies, referred to in No. 5 above, is the most significant development and one of which the farmers have been quick to take advantage. A few years ago when a farmer called on a power company to talk about service for his farm, it was often true that no one in the company knew anything about farm service. No rate for this particular kind of service had been devised and no one could guide him in putting electricity to work on his farm. The result was that he received scant attention. Today it is a different story when the farmer calls at the office of a progressive power company. He is referred to the Rural Electric Service Department and a man who knows his business explains the company's farm rate and its farm policy. Also that same individual is able to talk intelligently about how to put electricity to work on this man's particular farm; what kind of motors to buy; what kind of farm equipment he should have; is able to dissuade him from making foolish investments and to encourage him in purchasing the right kind of equipment. The whole experience is much in contrast to what it was a few years ago.

Numbers 6, 7 and 8 above deal with the development of an acceptable load on the farm. Many feared that the farmer never could be made a liberal user of electric energy. That fear represented a vital doubt for there is no way to extend electric service to widely scattered farm customers, if they are going to limit their use to a little current for lighting, or one or more minor applications on the farm. That is, there is no way by which this service can be rendered at a rate acceptable to the power company and at the same time not prohibitive to the farmer.

Development of many uses of electricity on the farm was, therefore, most vital and, to show that this development is being carried on successfully throughout the country, the Rural Electric Service Committee of the National Electric Light Association will soon issue a serial report giving the names and addresses of farmers all over the country who are using 3000 kw-hr. or more a year. At this writing, this information has been rereceived from more than 40 of our 48 states. Not only will the names and addresses of these farmers be given but, in addition thereto, for each one a brief outline describing the purposes for which he employs electricity.

Electricity Is Paying the Farmer

The last three numbers mentioned above concern another vital purpose. Obviously it would be utter folly for farmers to use ten times as much electricity as was common in the past just for the sake of earning a lower unit rate, hence the obligation to show conclusively that liberal and intelligent use of electricity on the farm is a good financial investment for the farmer.

In a general way, this is testified to by the experiences of power companies with farm customers who are employing electricity for many chores around the farm. I have talked to company managers and managers of rural electric service departments in many parts of the country and, so far, all have been unanimous in agreeing that their liberal farm users are the best satisfied customers. In fact, the more they use, the more enthusiastic they become.

B. F. Cornue of Renner, South Dakota, in an interview in a farm magazine, remarked that his electric bill ran about $22.50 and added that it was "the most delightful bill I pay." Mr. Cornue is using about 450 kw-hr. a month or more than 5000 kw-hr. a year. He

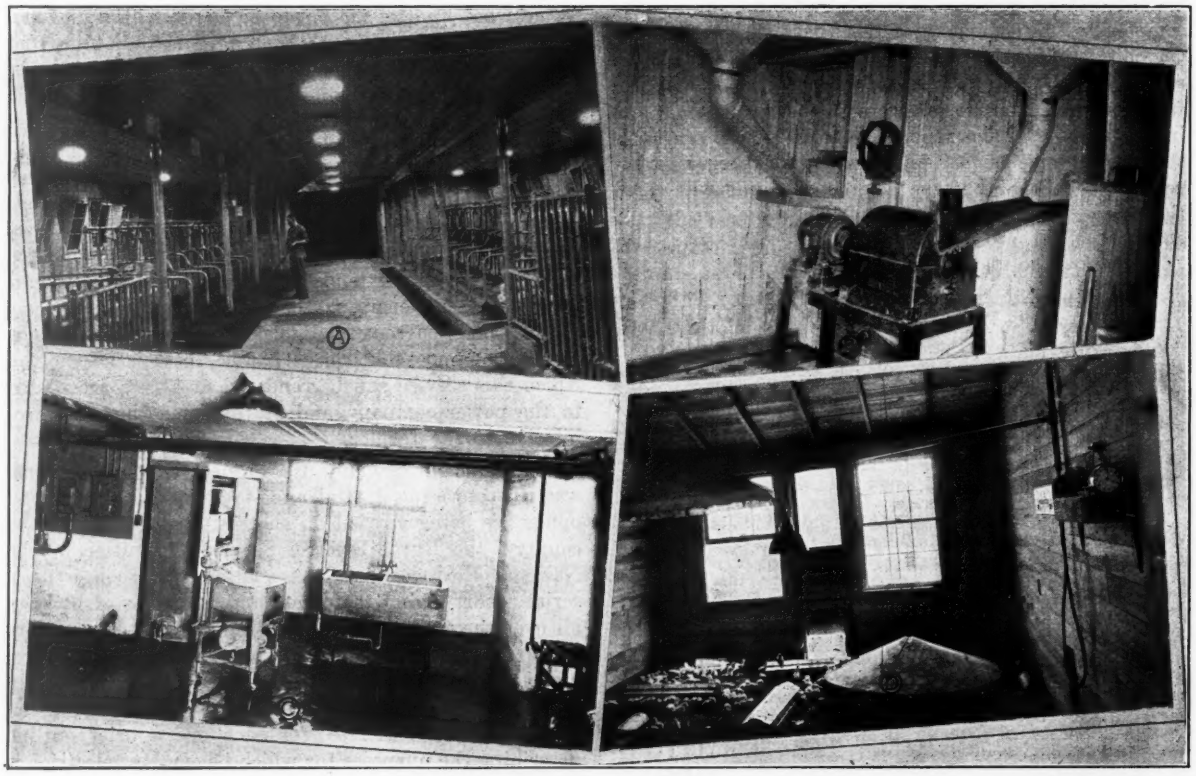
says that electricity is not only a joy and a blessing but that it relieves him of the cost of at least one additional farmhand. It is significant to note that the cost of such a farmhand with wages and board would amount to far more than Mr. Cornue's annual electric bill.

Figures from Red Wing Development

The most definite proof that we have today that electricity is a good business investment to the farmer is contained in the report of four years of electricity at Red Wing, now about to be issued by the University of Minnesota. While it is not claimed that all the improvement in the financial condition of these farms was due directly to the use of electricity, the fact remains that the financial condition of all five of these farms began to improve when electricity first was employed and that, as the silent servant was put to work at more and more jobs, the improvement in farm finances more than kept pace. It is the prediction of the University authorities that the end is not yet.

These farmers last year used an average of 243 kw-hr. per month per farm for which they paid an average monthly bill of $14.76. The report will show many instances in which electricity cut labor costs, or increased production, or both; it will show that the use of electric lights in the poultry houses on several of these farms alone provided an additional revenue in excess of the annual power bill. It will show that a motor on the well with running water in the house during the year releases some member of the farm family for 30 8-hr. days of productive labor. It will show that it takes 40 minutes a day to turn the cream separator by hand on a small dairy farm and that a motor eliminates this task, thereby releasing someone else for approximately 30 8-hr. days of productive labor.

This report will describe a modern barn built for electrical operation on one of the farms. The grain is threshed by electricity, elevated by electricity, dried and cooled by electric fans, ground and mixed by electricity, lowered to the cattle by gravity; the cows are watered and milked by electricity; the cream is separated by electricity. Only once, I believe, during the entire operation is the grain touched by human hands. It will show that electricity as applied to the cows, the chickens and the hogs, to the home, to the barn and to almost every farm operation outside of field work resulted in additional revenue, a saving, or both. These are substantial facts and well worthy of the consideration of every farmer in the United States.



ELECTRIC POWER GIVES; A. LIGHT, WATER SUPPLY AND MECHANICAL MILKING; B. FEED HANDLING AND GRINDING; C. WATER SUPPLY WASHING AND DRYING; D. HEAT AND VIOLET RAYS FOR THE CHICKENS

Back to the Farm with Electric Power

There is no accurate way to describe what electricity means in the home life of the farm family. When I say accurate, I mean there is no way of putting a dollars and cents value on it. Lights in the home provide cheer, comfort, convenience. They make the farm home a better place in which to live. A motor on the well makes possible a bathroom and running water,—modern sanitary conveniences.

The washing machine, the ironing machine, the ironer and all the other household appliances contribute their part to a better civilization on the farm. They

help to make life worth living. If it is important that the boys and girls be kept on the farm, certainly the conveniences of electricity prove a contributing influence. In fact, one may venture a step farther and say that electricity, as now utilized in agriculture, will tend to keep the farmer's wife on the farm and, just to take another step, will tend to keep the farmer on the farm.

Several specific instances have come to my notice where the advent of electricity was the determining factor in keeping the farmer and his wife on the farm and I have encountered other instances where electricity has brought the farmer and his wife back to the farm, after they had turned it over to a tenant and moved to a neighboring city.

I recall a middle-aged couple who had been living on a farm for many years. Their home was devoid of modern conveniences. They had accepted this condition because they were unfamiliar with anything else. Visiting relatives in a nearby city, they experienced the luxury of a modern day bathtub. This oddly enough brought it home to them that their own standard of living was far below that of city people and, as a result, they grew so dissatisfied that they determined to leave the farm. Just at this time, a farm line in this community became possible. This farmer was among the first to sign up for service. This is what he told me:

"The wife and I were going to move to the city. We had made up our minds that farm life without the modern conveniences in the farm home was not worth living. Electricity has changed our program. It makes possible a lot of conveniences—in fact, all the conveniences of city life. The first thing we are going to put in is a bathtub. We are content now to stay on the farm because electricity means that we can have all the conveniences of city life and at the same time retain all the advantages of farm life."

Much the same story has been told to me by farm people who turned their land over to tenants. They usually found tenants unsatisfactory but preferred this situation to living in a farm home devoid of modern conveniences. When electricity was made available to their farms, they soon got rid of the tenants, modernized their homes and got back on the land.

These experiences carry a strong suggestion that electricity on the farm may tend to reduce tenant farming in favor of owner occupancy.

Farms Offer Large Market for Equipment

Modern day application of electricity to agriculture is opening up a wonderful market to manufacturers. There are 6,500,000 American farms. It has been pointed out that, if they are to be served by the electric light and power companies, liberal use of electric energy is necessary. Liberal use means the purchase of equipment and the purchase of equipment means a market for the manufacturer.

Often, people ask how much of an investment is necessary to equip the average farm electrically. The figures are rather staggering. The list which goes to make up the total begins with farm wiring. Modern day use of electricity on the farm requires adequate light and power circuits; then come lighting fixtures and household electrical equipment. Frequently, it leads on to a furnace and almost always to a bathroom, because a motor on the well makes running water possible in the home. Then there is outdoor equipment. The five Red Wing farms on which the University of Minnesota reports are, of course, exceptional in this respect but will furnish some idea of what adequate equipment will cost. While most of the Red Wing equipment was loaned or donated by manufacturing companies, the University has listed it at regular retail prices. The total investment had all this equipment been purchased at retail was $16,667.

It sounds like a lot of money—more than $3300 per farm—but it is not a lot of money, if the farmer can use this equipment to his own advantage,—if it is a good business investment. On the other hand, while this may sound like a lot of money to the farmer, it spells a tremendous market to the manufacturer.

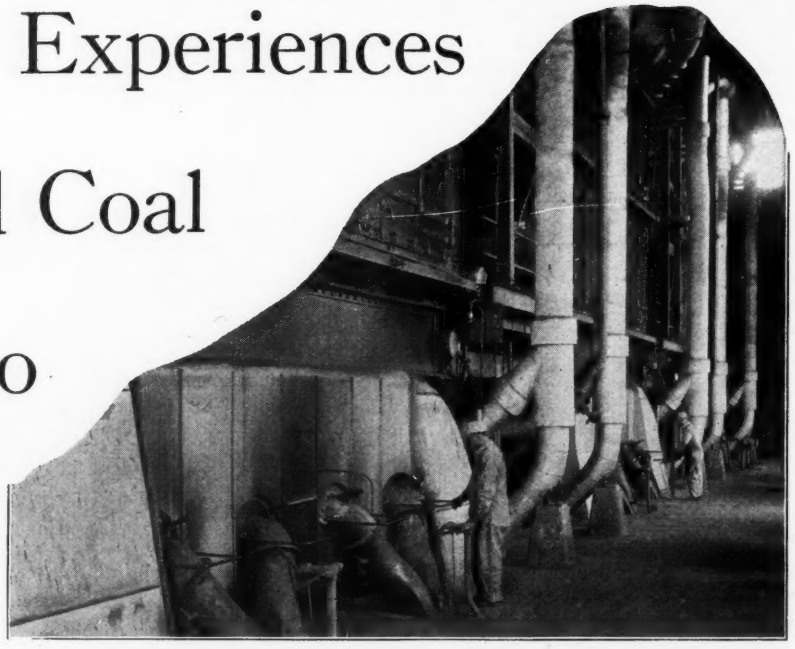
In seeking to determine all costs in connection with electric service, the University of Minnesota figured interest and depreciation on this equipment at 12½ per cent which would have called in 1927 for a charge of $2083 on this investment of $16,667. It is interesting to note that this overhead charge on equipment is really the most expensive part of power service, in that it is about two and one half times the amount these farmers paid the power company for current but even so, it did not prove prohibitive by any means because, as has been noted above, the improvement in the financial condition of these farms took care of the power bill and the fixed charges on all equipment, leaving a tidy profit besides.

It should be understood that in this list which goes to make up the total investment are included such items as plumbing, bathroom fixtures, several furnaces and other items which in the city are not regarded as part of the cost of electric service. The plumbing and bathroom expenditures were included because the motor on the well made them possible and the furnaces were included because the electric range had supplanted the coal or wood stove, which had been depended upon to heat the kitchen, so that some other type of house heating became necessary.

If the experience of these Red Wing farmers, duplicated as it has been by other farmers in other states who have made liberal and intelligent use of electric energy, can be repeated on all American farms, it makes this whole problem of extension of electric light and power company service entirely feasible. It spells a new type of agriculture, a higher standard of living, a higher type of farmer; in truth, a better civilization on the farm.

Temperature of the feed or suction water has an appreciable effect on the pumping ability and feeding limits of an ejector. Using steam at 135 lb. absolute, an ejector will pump 8 lb. of 40 deg. F. water per pound of steam against a pressure of 235 lb., but will only pump the same quantity of 90 deg. F. water against a pressure of 135 lb. This maximum pressure cannot be used to advantage, however, in actual service, because it is not stable. With 40-deg. water as above, the maximum pressure that is practical is about 170 lb., which gives a regulation of from 6 to 12 lb. of water per pound of steam.

Operating Experiences *with* Pulverized Coal *at* Kalamazoo



By

J. W. Mackenzie
and
R. G. Paddock

Consumers Power Co.

CONSTRUCTION of the Kalamazoo steam plant of the Consumers Power Co. was started October 1, 1926, and it was put into operation on June 1, 1927, thus setting a record for that company for rapid plant construction. When the plant was built, it was planned for the expected ultimate development at this site. On account of the excellent results obtained, however, the nature of load in this district and the acquisition of additional land, the plant may probably be increased in size.

Present plant was built for 20,000 kw. capacity and three boilers were installed to supply steam for the new unit and a smaller and lower pressure 3000-kw. unit in an older portion of the plant which is used for emergency service only. Each boiler contains 15,360 sq. ft. of heating surface and operates at 400 lb. steam pressure. The boilers are 24 sections (two tubes per section) in width and 20 tubes high, 14 rows above and six rows below an Elesco interdeck superheater. One tube in each of the four bottom rows in each section is omitted to form a slag screen. The omission of these tubes makes it the equivalent of a standard 18-tube-high boiler.

Construction of the Furnaces

Side and rear walls of the furnace consist of fin-tube, water-cooled surface; a water screen is provided across the bottom of the furnace to prevent clinkering of the ash. The total water-cooled surfaced in the walls of the furnace is approximately 1770 sq. ft., all of which is connected into the boiler circulation, thus giving a boiler unit having 17,130 sq. ft. of heating surface.

Directly above each boiler is a plate type preheater with ½ by ½ in. plate spacings, containing 21,600 sq. ft. of effective heating surface. The preheater reduces the temperature of the flue gases to 300 or 325 deg. final temperature and raises the temperature of air for combustion to 400 to 425 deg.

Coal Pulverizing Equipment

Coal pulverizing equipment consists of two 4-t. per-hr. unit pulverizers per boiler, located on the boiler room basement floor. Feeders were installed originally as an integral part of the mills but, due to difficulty in giving the fireman proper control over the feeding process, the feeders and magnetic separators have been moved up to the firing floor level. Mills are driven by 440-v., constant-speed, alternating-current motors at about 1150 r.p.m. Starting switches are in the basement near the motors but a tripping button is located on the boiler control panel on the firing floor. Coal feeder and magnetic roll separator on each mill are driven by a 1-hp., variable-speed, direct-current motor. The variable speed of the feeder motor is controlled through a resistance box. In addition, there is a two-ratio speed control between the motor drive and the feeder roll, which is controlled manually at the mill feeder. This arrangement gives a wide variation in possible feeder speeds and has proved extremely satisfactory.

Fans on the exhaust end of the mill shaft draw air through the mill for carrying the pulverized fuel out of the mill and, in addition, draw heated air from the main hot air duct. These two streams of air join at the discharge of the mill and constitute the primary air to the burners.

Manifold and Burner Arrangements

As originally installed, the discharge of each of the two mills per boiler joined in a common manifold just above the mills and this manifold was divided farther up into four pipes leading to the individual burners. As will be explained later, in the present installation there is no connection between mills; each mill supplies the two burners on its respective side of the furnace, that is the No. 1 mill supplies burners No. 1 and 2 and No. 2 mill supplies burners No. 3 and 4.

Each boiler is equipped with four, turbulent-type burners located in the front wall of the furnace just above the boiler room floor and arranged with the axis of the burner inclined downward at an angle of 20 deg. from the horizontal.

Each boiler has individual forced draft and induced draft fans, located on the air preheater floor above the boilers. These fans are driven by individual, variable-speed, alternating-current motors, arranged for a 50 per cent speed variation. Additional draft control is obtained by motor-operated dampers in both the forced and induced draft ducts, controlled by push and pull buttons on the boiler control panel.

Regulation of Pulverized Coal Fineness

One of the first difficulties experienced with the unit system was due to the coarseness of the pulverized coal. During the first few weeks of operation, the fineness obtainable averaged not over 35 per cent through a 200-mesh screen and the amount remaining on a 28-mesh screen often reached 4 per cent. Steps were taken at once to correct this trouble, by completely redesigning the air passages through the mills. One of the first steps was the reduction of area of the opening in the restriction rib after the last stage of the pulverizer.

This greatly improved the fineness for the smaller opening but made it necessary that the coal be more finely pulverized in order to be picked up by the air against the centrifugal force created by the hammers. The opening through the restriction rib was made cone-shaped and this tended to throw back into the mill most of the coarser particles. Later these cone-shaped restriction ribs were equipped with short, radial fins or teeth, which formed pockets around the periphery of the rib. These further broke up the escaping air stream, resulting in the coarse coal being left behind in the pockets or thrown back into the path of the hammers. By these changes, the pulverization has been greatly improved and in present operation approximately 70 per cent through a 200-mesh screen is obtained, with less than half of one-half per cent of coarse coal left on a 28-mesh screen.

Experiments with Exhaust Fan Blades and Mill Hammers

This added restriction in the mill increased considerably the tendency for the mill to plug up when the coal happened to have an unusual amount of surface moisture. It was attempted to correct this trouble by installing longer dust blades on the exhaust fan but, for reasons given later, this practice was discontinued. With the added restrictions in the mill and the long dust blades, the power consumption was materially increased. No data previous to the changes are available but afterwards the power consumption per ton of coal milled was from 22 to 27 kw-hr. measured as electrical input to the driving motors. This includes the power for feeding, pulverizing and moving the fuel and primary air into the furnace. The coal used during the time these readings were taken was from the Eastern Kentucky field.

During the process of experimenting with the mills, different types of hammers were tried. Originally the mills were supplied with two-piece hammers bolted axially to a holder riveted to the periphery of the disk which formed each stage. The bolt head and nut were behind the head or main wearing portion of the hammer and this reduced the wear on the bolt so that there have been no failures caused by bolts wearing to the breaking point while the mill was in service. Another type of hammer made in one piece was tried out but, in this case, the bolts extended radially through the head or main wearing part of the hammer. This exposed the bolt head to excessive wear and the bolt holes also weakened the hammers to such an extent that several hammer failures occurred. The original two-piece hammers were then replaced and have been used since that time. Only two cases of hammer failure have been noted with the two-piece hammers and one of these

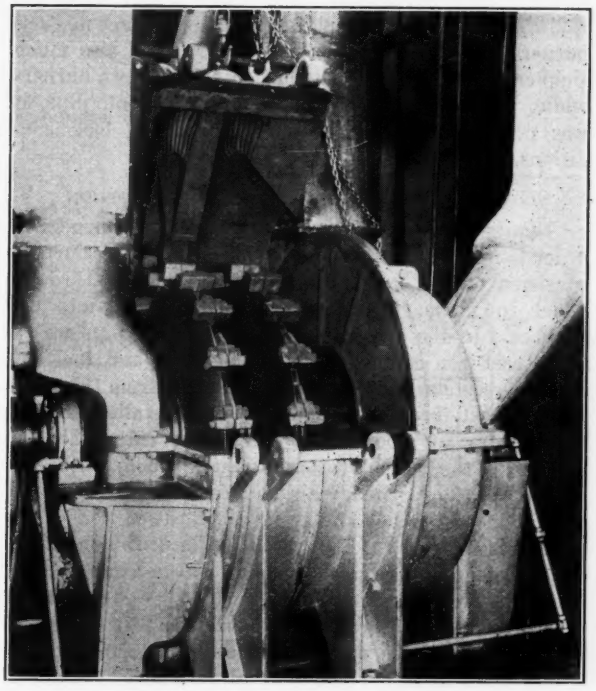


FIG. 1. ONE OF THE PULVERIZING MILLS, SHOWING TWO-PIECE HAMMERS AND SPECIAL RESTRICTION RIBS. FEEDER MECHANISM HAS BEEN MOVED TO THE FIRING AISLE

cases was definitely chargeable to a piece of steel left in the mill when it was open for replacing parts.

Hammers made of several different materials—cast steel, cast iron, chilled cast iron and white iron castings—have been used. To date the chilled cast-iron hammers have been found satisfactory but white iron hammers are now being tried.

Maintenance on the mills has not been excessive. The average set of hammers will pulverize about 2500 t. of coal before they are worn so as to require replacement. Liners have never been changed since the mills were installed. The disks are beginning to wear to such an extent as to require replacements. No changes to fan blades or dust blades have been necessary, except such as were made during the experimental period.

As noted before, it was found necessary to separate the discharge pipes on the two mills for each boiler.

With the discharge pipes from the two mills tied together, it was difficult to get even coal distribution to the four burners. It also necessitated the installation of gates absolutely tight in the discharge of each mill, to keep the pulverized fuel from one mill which might be running from sifting into the idle mill. Great care was necessary in starting the second mill to prevent dust explosions. The opening of these gates also introduced quite a little delay in getting a mill into operation. The loads which the plant could carry were definitely limited, for the load per boiler could not drop below about 5000 kw. without the fire in one or more of the burners going out due to fluctuations in coal distribution.

Since cutting the mills apart, it is possible to carry as low as 2000 kw. with only one mill and two burners in operation. No damage to the idle burners has occurred, even when the dampers for admitting air to these burners have been completely closed. It is also much simpler to get uniform distribution between two burners while, with four burners fed from a common pipe, it was practically impossible under changing load conditions.

Changes in Burners Improved Combustion

Numerous changes have been made to the burners in order to improve the combustion efficiency. The burners consisted of a central pipe 12 in. in diameter through which the primary air and fuel were passed into the furnace. In the center of the primary air pipe was a large, cast-iron cone which spread the air and fuel out into the secondary air stream which came from the main hot air duct through stationary vanes installed around the primary air pipe. These vanes imparted a whirling motion to the secondary air stream, which, with the conical spray of primary air and fuel, was expected to give great turbulence and rapid combustion.

It was soon noted, however, that the turbulence was not sufficient to give rapid combustion and that a long flame resulted, causing dangerously high steam temperature out of the interdeck superheater. In addition, considerable trouble was experienced with burning out of the cones in the primary air pipes. After considerable experimenting with different types of cones, a wheel having six curved vanes was substituted for the cone. This wheel was placed inside and near the outlet end of the primary coal pipe. This shortened the flame somewhat and reduced the steam temperature.

Results of Tests After Burner Changes

Sufficient turbulence was still lacking, however, to give complete combustion and considerable loss resulted from unburned carbon in the fly ash. Several changes in secondary air vanes were made and finally the size of the secondary air opening was materially reduced and the vanes shortened, in order to impart a higher velocity to the air and to bring the secondary air stream in closer to the primary air stream. This increased turbulence and improved combustion conditions. The steam temperature was lowered still more, this time to a point below the expected operating condition.

Evaporative tests run after the burners had been changed showed good results when the CO_2 was not carried too high. One series of tests was run with CO_2 at the boiler outlet averaging 15 per cent or slightly higher. On these tests, the primary air pressure was carried at a maximum and the remaining air taken in as secondary air. Under these conditions, the efficiencies ran from 81.9 per cent to 83.4 per cent. The unburned carbon loss was high and it was decided to repeat the tests with lower CO_2 and less primary air. Tests at 14 per cent CO_2 gave results of 87.6 and 86.7 per cent. At 12 per cent CO_2, the efficiency was reduced to 85.7 per cent. These tests indicated, that the most efficient CO_2 is somewhat lower than is usually promised by the manufacturers of pulverized fuel equipment. It will be noted that better efficiency was obtained at 12 per cent CO_2 than at 15 per cent. This was due wholly to the reduction in unconsumed carbon losses.

Later experiences have confirmed the deductions made from the tests. Turbulence in this type of burner is best produced by high velocity in the secondary air stream. This produces a better mixture at the burner outlet and combustion is more rapid and complete. On the other hand, low primary air velocities give better results than high velocities. It seems that high velocities carry the pulverized fuel completely through the secondary air stream and the burning is not completed near the burner tip but the flame is long and there is a high percentage of unburned carbon in the fly ash results.

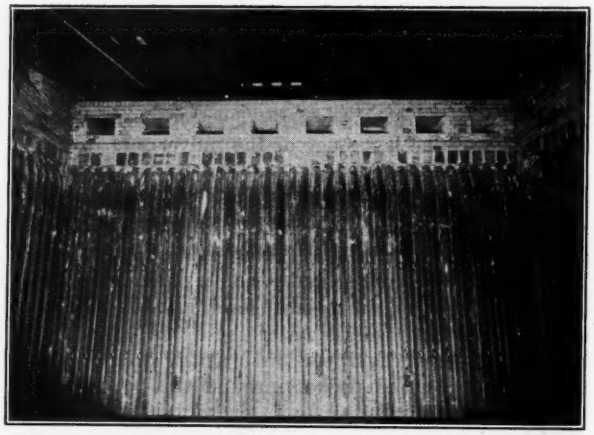


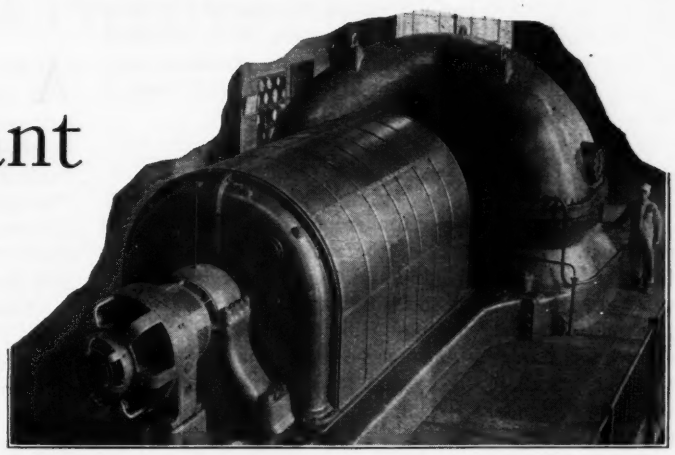
FIG. 2. REAR WALL OF A FURNACE SHOWING FIN TUBES AND WIDE SPACING OF BOILER TUBES TO FORM SLAG SCREEN

Mill Drying Eliminated Clogging

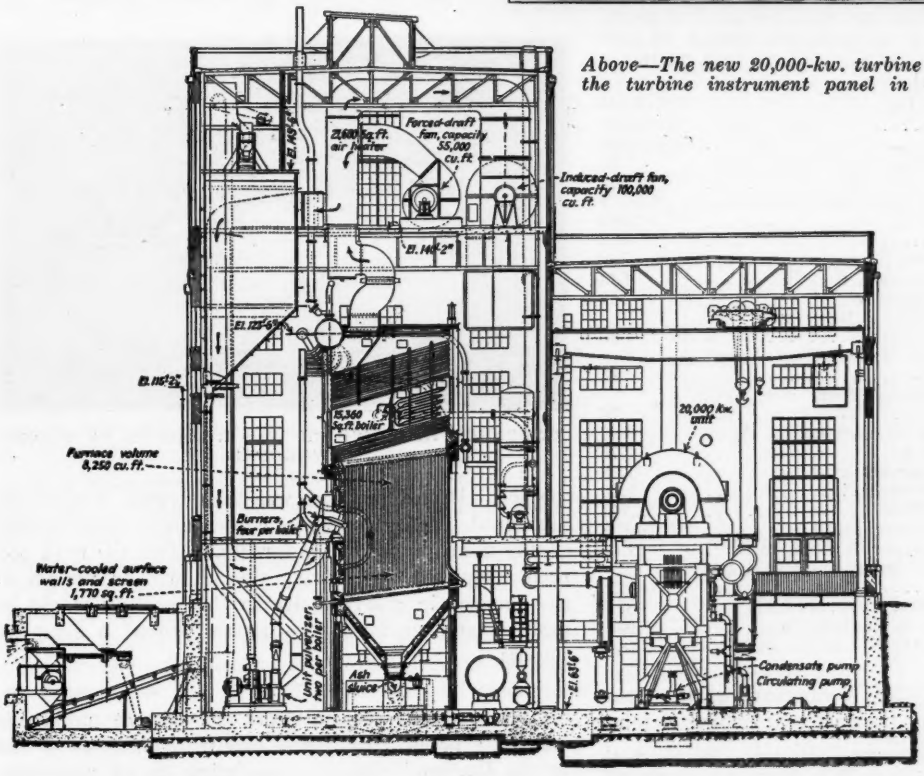
As shown before, the added restriction in the mills increased the tendency for the mills to plug up when the coal was wet. This was first offset by increasing the length of the dust blades on the exhaust fans so as to pull more air through the mill. This method, however, gave too high a primary air pressure at the burners. Accordingly it was decided to use the short dust blades again and to dry the coal in the mill to stop plugging. At the time that the feeders were moved to the boiler room floor, a small duct leading from the hot air duct was cut into the coal pipe to each mill between the feeder and the mill. A damper in this line is manipulated so as to give a slight negative pressure at the mill inlet. By this arrangement, all the carrier air is now taken from the hot air duct, whereas hereto-

Kalamazoo Steam Plant

Simplicity of equipment and arrangement are features of the plant. Extremely satisfactory and reliable operation has resulted, despite the fact that the plant has been used largely to carry fluctuations in the system and to regulate frequency.



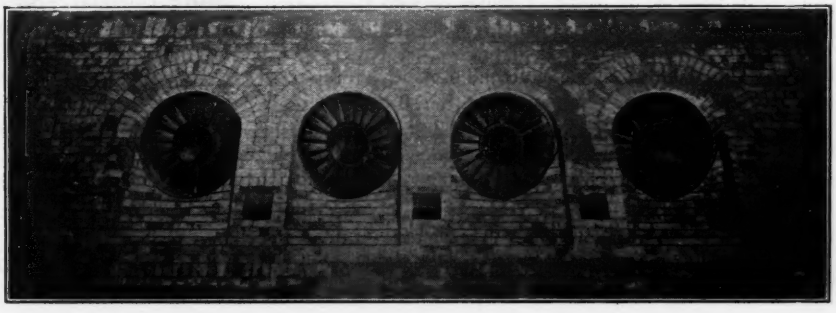
Above—The new 20,000-kw. turbine generator, with the turbine instrument panel in the background



Above—Cross section through new 20,000-kw. plant, showing details of furnace and boiler, pulverizing equipment and accessories

Above—Present burners; note changed air vanes and vaned wheel in coal pipe

Below—Front wall of furnace showing original burners, with central cones removed



fore it has been taken in at room temperature. Drying the fuel in the mill has eliminated plugging of the mills. In addition, the present arrangement gives excellent control over the primary air pressure, because practically all of the primary air is the carrier air through the mill and this is under damper control.

Operating Results Good Despite Experimental Work and Unfavorable Load

Notwithstanding the number of changes and experimental work carried out on the equipment in this plant, it has always been reliable and has carried its share of the system load from the time it was first started. It has been extremely flexible in its ability to pick up and drop loads suddenly and has been used largely to carry the fluctuations in the system load and to regulate the system frequency. In spite of these unfavorable load conditions, the efficiency results have been very good.

OPERATING RESULTS AT KALAMAZOO STEAM PLANT. AVERAGES FOR 12 MOS., NOV. 1, 1927, TO OCT. 31, 1928

1. Kw-hr. Gross Machine Output	85,318,600
2. Kw-hr. to Auxiliaries	6,174,740
3. Kw-hr. Net Generation	79,143,860
4. Percent Power to Auxiliaries	7.24
5. Maximum Total indicated kw.	22,000
6. Number Hours Station Generating	7,130.7
7. Average Load on Station, kw.	11,965
8. Load Factor, per cent	44.3
9. Average Steam Pressure, lb. gage	368
10. Average Steam Temperature, deg. F.	683
11. Temperature of Feed Water to Boilers, deg. F.	289
12. Temperature of Inlet Circulating Water, deg. F.	53
13. Temperature of Outlet Circulating Water, deg. F.	63
14. Temperature of Condensate from Hot Well, deg. F.	76
15. Average Back Pressure on Turbine, in. Hg.	0.93
16. Lbs. Water per net kw-hr.	12.76
17. Lbs. Generating Coal per net kw-hr.	1.28
18. Lbs. Total Coal per net kw-hr.	1.30
19. B.t.u. per lb. Coal as Fired	12,771
20. B.t.u. per net kw-hr. (Generating Coal)	16,338
21. Equivalent Evaporation per lb. Coal, lb.	11.03
22. Equivalent Evaporation per sq. ft. W.H.S. per hr., lb.	6.26
23. Boiler Efficiency, percent	83.8
24. Banking Coal per b.hp.-h. Banked, lb.	0.20

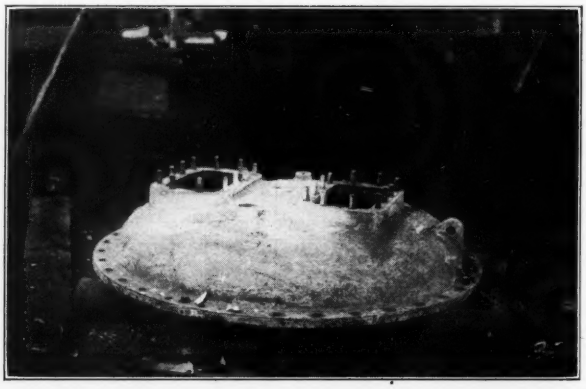
Accompanying table gives a summary of the principal operating results for the past year ending October 31, 1928. Although the plant went into operation in June, the operation for the first five months is not covered in this table for several reasons, chief of which is that the records for that period are not considered reliable because of troubles experienced with feedwater meters and the weighing and sampling of the coal. In addition, the changes in equipment and experimental work done resulted in lower efficiency during this period.

December sales of mechanical stokers as reported to the Department of Commerce by the 10 leading manufacturers in the industry, totaled 102 stokers installed under boilers of 49,212 hp. as compared with 116 stokers under 30,938 hp. in November and 83 stokers under 32,202 hp. in December, 1927. Of the 102 stokers installed in December, 1928, 34 were installed under fire tube boilers of 5111 hp. capacity and 68 under water-tube boilers of 44,101 hp. capacity.

Condenser Head Bronze-Welded

At the plant of a starch refining company, the head of a condenser used in the refining process suffered an 18-in. break and it seemed probable that a serious loss would result, as the head was an intricate casting and would have been very costly to replace. The plant welder was called in and after looking over the piece and examining the nature of the break, decided that it would be best to preheat, owing to the size and design of this job, and bronze-weld.

Consequently a furnace of loose fire-brick was built up. The condenser head was placed in the center of this temporary preheater, the base of the piece resting on two 6-in. pipes. After cleaning the crack thoroughly with a stiff wire brush, a charcoal fire was lighted under the casting and an asbestos paper covering placed over



CONDENSER HEAD WHICH WAS REPAIRED BY BRONZE WELDING

the job. Bronze welding was then begun, a standard high grade bronze rod being chosen and a good quality of flux used to float off impurities. After the weld had been completed, the casting was allowed to remain in the furnace in a dying fire so that cooling would be gradual and uniform; the repair proved a complete success.

Accident prevention work in cement mills has reached a noteworthy degree of effectiveness, according to the Portland Cement Association, in an announcement that 18 mills owned by 12 different companies operated in the United States and Canada throughout 1928 without a single lost time accident. Each of these plants will receive the Association sculptored concrete trophy awarded annually to cement mills operating the entire calendar year free from mishap. In 1927, 10 plants won trophies, or more than twice as many as had accomplished the feat since accident records of the industry had been kept. The 1928 trophy winners number more than the total of all previous winners. Of the 150 competing mills, three have received the trophy for two consecutive years, a remarkable record in accident prevention, the announcement points out. They are located at Ironton, O., Cowell, Calif. and Iola, Kan.

It is our actual work which determines our value.—Geo. Bancroft.

Coal Carbonization as Prepared Fuels Source--II*

Low Temperature Processes, Products and Outlook. By A. A. Potter† and H. L. Solberg††

CHARACTER of the coke, gas and by-products recoverable from coal gas depends upon the kind of coal, the rate of heating and the maximum temperatures involved. All of the coal carbonized in this country on a successful commercial scale is treated in retorts or ovens where the temperatures are from 1800 to 2200 deg. F. Such temperatures are necessary in order to produce a strong, metallurgical coke or in order to produce the maximum amount of gas which will conform to the legal requirements in regard to heating value.

Table I. Quantity and Composition of Gases Produced by High and Low Temperature Distillation

	High Temperature	Low Temperature
Cubic feet of gas per ton of coal	11,000–13,000	4000–5500
B.t.u. per cubic foot	525–600	675–800
Hydrogen in per cent	50.0	27.5
Methane in per cent	33.0	48.0
Illuminants in per cent	3.0	10.0
Unsaturated hydrocarbons	...	3.1
Carbon monoxide hydrocarbons	5.5	7.3
Carbon dioxide hydrocarbons	1.5	2.5
Nitrogen and oxygen hydrocarbons	7.0	1.6
	100.0	100.0

Volatile hydrocarbons in the form of gases and tars which are driven from the coal undergo thermal decomposition or cracking when heated to about 1200 deg. F. This can only be prevented by using a maximum retort wall temperature of about 1200 deg. F. Table I, by W. H. Blauvelt, shows the difference in the composition of gases obtained by high and by low temperature distillation. The heating value of the gas is decreased by cracking and the hydrogen content of the high temperature gas is greater because of the decomposition of the hydrocarbons such as methane and the illuminants into free hydrogen and carbon. The carbon so produced is deposited on the surface of the coke. Due to the more thorough heating of the coal and the cracking of some of the tars to form gases, the gas yield from high-temperature carbonization is more than twice that obtainable from the low-temperature method. Table II, by A. C. Fieldner, shows the yield per ton of coal of the various products obtainable by the two methods. Low-temperature coke is a weak and friable coke, therefore unsuitable for metallurgical purposes, but can be made into an excellent smokeless fuel as a substitute for anthracite. It contains a sufficient amount of volatile material to ignite readily. Coke produced by many of the low temperature processes now undergoing development, however, is unsuitable for sale as a domestic fuel to compete with anthracite without briquetting.

Low-temperature carbonization produces from two to three times the amount of tar recoverable by high-temperature treatment. About the same quantity of gasoline substitutes can be obtained by either method. Low-temperature tars, however, are not as well understood as those obtainable from high-temperature distillation and it seems that they are not as valuable in manufacturing industries. Their price is controlled at present by the price of fuel oil and is only about five cents per gallon.

Annual production of coal tar in the United States is about 550 million gallons. About 60 per cent of this is burned directly as fuel and the rest is distilled, the quantity distilled being limited by inability to market the pitch residue. About 40 per cent of the cresylic acid and cresols used in the United States are produced from coal tar and the rest are imported; 20 per cent of the phenol is obtained from coal tar and the remainder is produced synthetically. The topping or fractional distillation of the lighter part of high-temperature tars now produced would more than supply the present market for these products. The figures are from a paper by Robert M. Crawford before the 1926 International Bituminous Coal Conference.

Objects in Low-Temperature Carbonization

In developing a process for low-temperature carbonization, the principal objectives are as follows: 1. To produce a smokeless domestic fuel. 2. To produce a gas of maximum heating value. 3. To produce the maximum amount of tars and oils. 4. To recover the gas, oils and tars from coal before burning it as a fuel for steam generation in power plants. In comparing the yields of products obtainable by high and low-temperature carbonization, it is seen that low temperature carbonization yields less gas and ammonium sulphate but more tars and coke. At present, these tars command a low price on account of cheap petroleum but this condition may be altered within a few years. Some of the tar derivatives such as creosote, have, however, a rather limited application and it is probable that extensive development of low-temperature carbonization processes would glut the market with such products.

Table II. Yield from Coal Treated by Low Temperature Carbonization

	High Temperature Carbonization	Carbonization, Externally Heated Retorts	Carbonization, Internally Heated Retorts
Coke, per cent	60–70	70–80	60–75
Volatile matter in coke, per cent	1–2	7–15	7–15
Gas, cubic feet per t.	11,000–12,000	3000–5000	20,000–50,000
Calorific value of gas, B.t.u. per cubic foot	520–550	800–1000	150–250
Tar, gallons per t.	10–12	20–28	18–20
Specific gravity of tar	1.19	1.07–1.09	1.02–1.07
Light oil for motor fuel, gal. per t.	2.5–3.0	2.5–3.0	None
Ammonium sulphate, lb. per t.	25–30	10–12	12–18

Low-temperature carbonization processes seem to have two fields in which successful commercial development may take place in the future: 1. In the manufacture of a smokeless domestic fuel from lignite, sub-

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†Dean of Engineering, Purdue University.
††Assistant Professor of Mechanical Engineering, Purdue University.

bituminous coal and the screenings from bituminous coal. 2. The recovery of the gas and by-products before burning the carbon residue under steam boilers. In the first case, a high-grade domestic fuel can be made from a low-grade fuel which at present commands a low price and, in the second place, the sale of the by-products should reduce the cost of the fuel burned for the generation of steam.

Difficulties in Low-Temperature Work

Principal difficulties encountered in the development of a commercial process for the manufacture of low-temperature coke are as follows:

1. Coal is a poor conductor of heat. In high-temperature carbonization, with a retort wall temperature of 2000 deg. F., the fusion zone travels at the rate of only about ½ in. per hour. In low-temperature carbonization, with the wall temperature limited to about 1200 deg. F., the rate of carbonization is so slow that it is impossible to carbonize coal at an economical rate, if the thickness of the coal to be carbonized is more than 4 or 5 in.

2. When the hot carbon residue is discharged from the retort, it contains sufficient volatile matter to ignite immediately, if exposed to the air. Most of the bonding or coking qualities of the coal are destroyed by slow heating at the low temperatures employed and, if the coke is quenched with water as it is discharged from the retort, it will disintegrate to a powder. Consequently, quenching of the carbon residue by means of water must be avoided.

Low thermal conductivity of coal presents the most serious difficulty in the way of a successful process. Reducing the thickness of the layer of coal which covers the wall of the retort decreases the capacity of the carbonizing equipment and increases the cost of an installation of a given capacity. A number of experimental plants have been built with horizontal, inclined or vertical stationary retorts which are heated externally, with an internal screw agitating the coal to bring new surfaces continually into contact with the hot walls of the retort. Raw coal is fed in at one end and the carbonized residue is discharged from the other end. Internal stirring devices have caused considerable trouble due to breakage caused by sticking of the fused coal in the retort.

Another type of retort upon which considerable experimental work has been done, particularly in Europe, is the externally-fired, revolving cylindrical retort, somewhat similar in appearance to a cement kiln. In some cases, hot gases such as producer gas, have been passed through the retorts in order to heat the coal by direct contact. Such internally-heated retorts are open to the objection that the rich coal gas is diluted by the gases used to heat the coal so that one of the principal advantages of low-temperature carbonization, the high heat value of the gas, is lost. In all cases, the difficulty of heating the coal rapidly at the low temperature used, has constituted a serious problem.

Pulverized Coal Carbonization

In order to speed up the heating process, the carbonizing plant installed in connection with one public utility power plant utilizes the principle of carbonizing powdered coal in two stages in internally heated retorts. In the first stage, the powdered coal, 65 per cent of which will pass through a 200 mesh sieve, is allowed to fall through a vertical retort in the form of a dust cloud. Hot waste gases at about 700 deg. F. pass upward through the coal to preheat and dry it. Because of the large surface presented by the finely divided coal, the heating is rapid and thorough. The coal dust settles in the bottom of the upper retort and is fed into a second vertical retort where it is heated in direct contact with gases at about 1100 deg. F., a part of the coal gas being burned to supply the heat necessary to carbonize the powdered fuel.

Although this hot gas mixes with the gas distilled from the coal and thereby dilutes it, the heating value of the resulting mixture is about 550 B.t.u. per cubic foot and compares favorably with that of gas obtained by high temperature carbonization. It is believed that the carbon residue which collects in the bottom of the retort can be burned directly as powdered fuel without further pulverizing. Should this process prove to be a commercial success, it will undoubtedly have a marked influence on power plant design and operation as the selling price of the gas and the by-products recoverable from the gas should produce a substantial profit.

From 2.5 to 3.0 gal. of benzol can be recovered from the tars and gases distilled from coal by the low-temperature carbonizing process. This may be blended with gasoline or alcohol or both to form a satisfactory fuel for automobile engines but will never be an important substitute for gasoline. The principal objection to using straight benzol as a fuel is its cost and high freezing temperature, about 40 deg. F.

In the N. E. L. A. Prime Movers' Committee's report on Distillation Products of Coal (July, 1928) a review is included of the various plants for the carbonization of coal. Of particular interest are the White and the Parr experimental plants. In the White process, instantaneous carbonization of crushed coal takes place. The fuel is dropped through a vertical retort heated to about 2000 deg. F. The yield per ton of coal includes about 6000 cu. ft. of gas of 600 to 700 B.t.u. per cubic foot, about 170 lb. of tar and a coke residue which is readily burned in pulverized form. The Parr process also utilizes a crushed fuel and its objective is to coke coals which cannot be coked by other processes. The yield per ton of the Parr process includes about 9000 cu. ft. of gas of 700 B.t.u. per cubic foot, 20 gal. of low-temperature tar and coke which represents 65 to 70 per cent of the original weight of the coal charged.

The future of low-temperature carbonization of coal is doubtful. The development of successful carbonizing processes which will involve a moderate investment, reasonable operating costs and high capacity, is still in the experimental stage. If the technical difficulties can be solved, there still remains the problem of developing a market for the low-temperature coke, probably in competition with anthracite as a domestic fuel. In any case, the value of the coke residue and the tars, gases and oils must be greater than the cost of the original fuel plus the cost of preparation before the process can be a commercial success.

It is now generally recognized that air preheater investments are justified because of the heat economies and improved furnace conditions that they effect.

Tailored Power Plants for Modern Buildings

MECHANICAL EQUIPMENT SHOULD BE FITTED TO SERVICES REQUIRED AND UTILIZE BEST MATERIALS AND DESIGNS. BY C. S. MILLARD*

NO LONGER does just any kind of mechanical equipment serve for modern buildings as many factors are involved, depending upon the purpose for which the buildings are to be used. Installations vary from a simple heating plant to a complex power plant

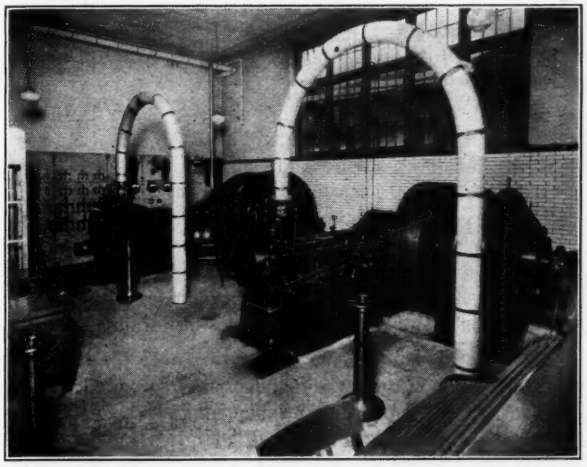


FIG. 1. THIS EXAMPLE OF GOOD FITTING IS KEPT CLEANED AND PRESSED

such as may be required for a hotel, hospital, office building or large industrial plant. With improvement in the construction of all types of buildings, has come corresponding advancement in the complicated mechanical equipment that plays so important a part in structures of all classes, as can be better appreciated if one compares the equipment in many of the older industrial power plants, with those of more recent design.

MANY OLDER PLANTS ARE INADEQUATE

Examination of many of the older industrial plants reveals mechanical equipment that is woefully inadequate, largely due to the fact that installations which were sufficient at the time the original plant was built, have been added to in a haphazard manner to take care of plant additions, without proper regard to the capacities of generators, boilers, piping, pumps or other equipment. This chaotic condition is due to the lack of proper engineering advice and future planning in the early stages of the development.

Power plant, or if it be only a heating plant, is often looked upon by the management as a necessary evil. Antiquated boilers and engines of inefficient type are still doing duty. In many instances, spare equipment no longer exists, even if originally provided. Most of these industrial plants are without recording instruments, so that there has been no adequate means of checking up on efficiency of the equipment. Where process steam is used, often the amount is an unknown quantity, no means being provided for measuring it.

*Chief Mechanical Engineer, Frank D. Chase, Inc., Engineers and Architects, Chicago, Ill.

NEEDS OF EACH CASE SHOULD BE STUDIED

Design of modern industrial plants requires a careful analysis of the present and future requirements, to provide the proper mechanical services. In the location and design of the power or heating plant and service piping of various kinds, the possible future growth of the plant is to be considered, and space provided for possible extension of the power plant for future needs.

In a large number of industries, such as machine shops and foundries, a heating plant may be all that is required. With the low price of power and light available in many industrial centers, it is the practice to purchase these services, so that the only function of the boiler room is to supply heat.

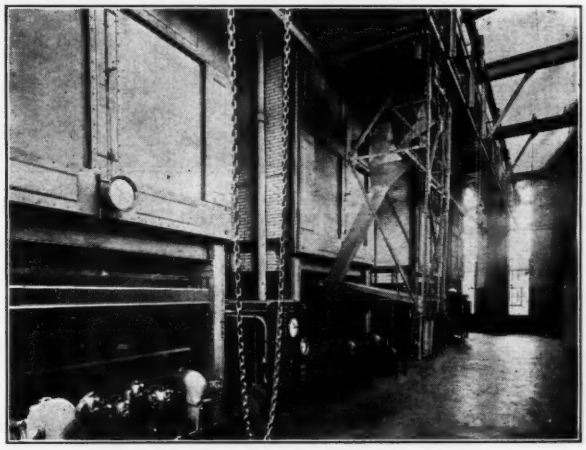


FIG. 2. FOR A LARGE BUILDING PLANT ADEQUATE FUEL HANDLING EQUIPMENT SIMPLIFIES OPERATION AND AIDS HOUSEKEEPING

Where process steam is not required, low-pressure boilers generally serve in plants of moderate size. These are cheaper in initial cost and maintenance, have less depreciation, and can be accommodated in a smaller boiler room than high-pressure boilers. It is becoming quite common practice to equip such boilers with stokers or oil burners. Coal and ash handling equipment, though generally not a part of the average small industrial plant, should have consideration. Outside of the heating boilers, the boiler plant equipment is simple; there is an electric-driven automatic vacuum pump for the heating returns, possibly a motor-driven house pump and an air compressor installation, for compressed air is a necessity in most plants.

In the newer industrial buildings, unit heaters are being used for heating and cooling and have proved most satisfactory. They are reasonable in first cost and in operating cost and give a uniform distribution of heat. Temperatures can be brought up to normal much more rapidly in the morning with unit heaters than

with direct radiation. Also added economy can be secured by equipping the unit heater motors with thermostatic control.

High-Pressure Best for Larger Plants

In large industrial plants, consisting of widely scattered buildings, high-pressure steam is more generally used for heating on account of the saving in pipe sizes in the long distributing mains. For direct radiation in the offices, the steam pressure is controlled by reducing valves but unit heaters in the shops are operated to

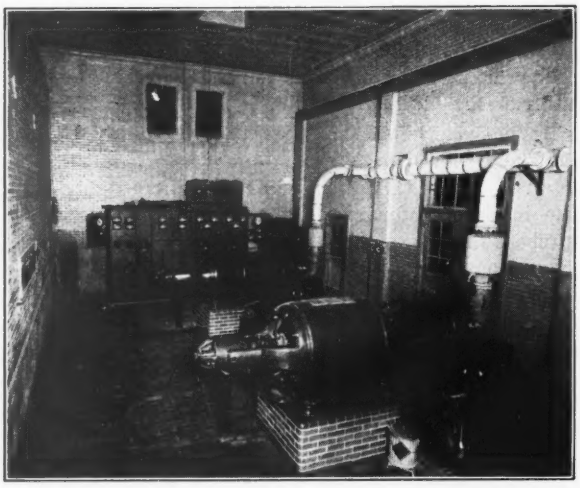


FIG. 3. INDUSTRIAL PLANTS SHOULD BE WELL PLANNED AND MAINTAINED TOO

advantage on high or intermediate pressures, reducing the sizes or the number of heaters required, consequently the initial cost of the system.

Separate High and Low-Pressure Plants May Be Justified

Industries using process steam may justify an elaborate power plant, depending upon the size of the plant and the quantity of steam required. In some industries, where the process steam requirements are quite limited, the high-pressure steam is supplied by a small high-pressure boiler, the remainder of the plant consisting of low-pressure heating boilers. If a large amount of power and process steam is required, it is generally cheaper to generate power than to purchase it. Sometimes the money necessary for the initial cost of generating equipment, however desirable, is not available and plans have to be changed accordingly.

High-pressure steam required for process purposes may be taken from the exhaust of non-condensing turbines or engines operating at high back pressures, or from bleeder turbines. The proper equipment for any given condition requires careful analysis and involves the relation between the power requirements and the amount and uniformity of the process steam load. Greater economy is possible with the more uniform loads. With widely fluctuating steam demands, the application of the steam accumulator should be productive of economy, although this type of apparatus has not been used to any great extent in this country.

Design of the industrial power plant has been affected to a considerable extent by the development of the steam turbine. Keener competition of the public utility companies is possible through the improvements of the condensing turbine, while the improvement of the non-condensing and bleeder turbines has enabled many manufacturers to reduce costs. In many of the large industries, improvements in power plant equipment are keeping pace with the latest development in boiler design, resulting in economies comparable with central station practice.

More Power and Better Lighting

In the applications of power and light to the industrial building, there has been noticeable tendency in many plants toward individual motor drive for many machines.

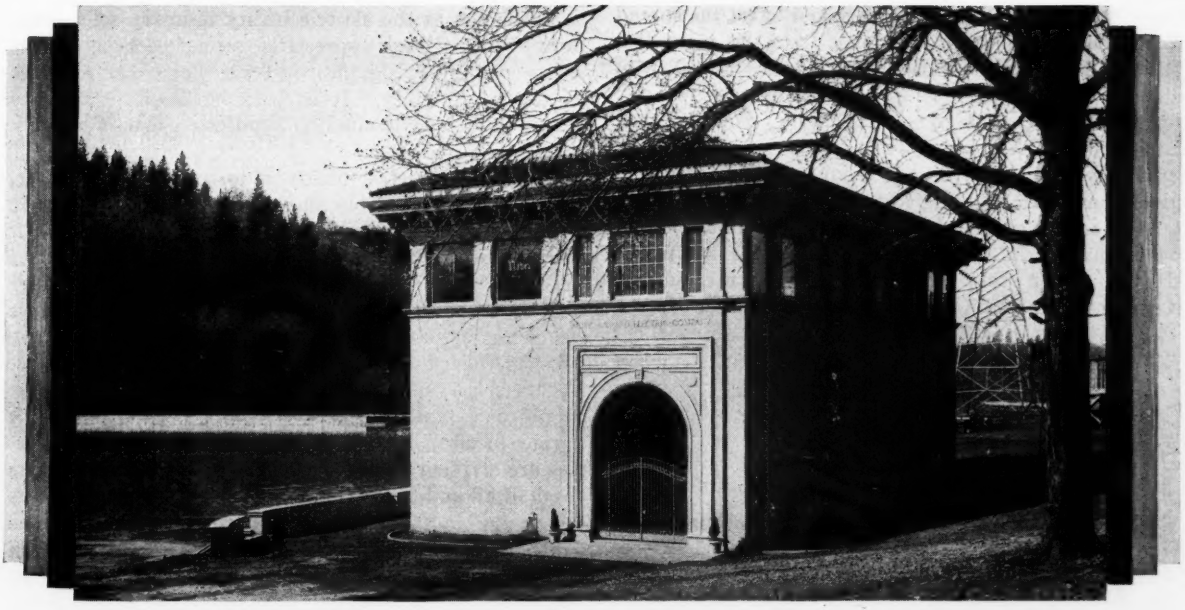
A great advance has been made in shop lighting. Intensities of illumination have been on the increase, with the result that the modern factory is far better lighted than the older type. It has become more generally appreciated that well lighted plants tend to increase the efficiency of the employes and that, in designing the lighting system, it is necessary to vary the intensities in accordance with the particular type of work that is being carried on in the building.

Many large hotels have complete power plants, generating their own power and utilizing the exhaust steam for heating the building and heating hot water, large quantities of which are required. High pressure steam is used for kitchen service, even when power and light are purchased.

In addition to steam and power requirements, buildings of this type require an extensive system of ventilation. Some of the more important rooms are supplied with cooled air in summer, which involves a large refrigerating plant, used also for ice manufacture and refrigerator service. Elevators, dumbwaiters, telephones, hot and cold water piping and fire protection systems, are a few of the problems that the mechanical engineer has to solve, made more complicated in many cases by the limited amount of space available.

Office buildings in our large cities vary widely in their power plants. Steam is purchased in many instances, also power and light in a large number of the new buildings. The heating load is handled by high-pressure boilers operating with stokers in many large buildings. Other buildings have low-pressure heating boilers, both with and without stokers. In new installations, recording instruments and radiators thermostatically controlled, or other steam saving devices, have led to considerable savings in fuel.

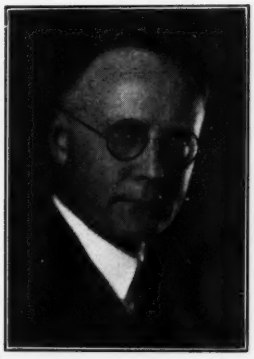
More and more in buildings of the future will competition in industrial lines require owners to give attention to the power plant. In the future, smaller industrial plants may be grouped together, receiving power and steam from a district station supplying a limited area, where the initial expense of individual efficient power plants cannot be met. Many owners are now appreciating the value of more efficient equipment and it is the province of the engineer to educate owners in the matter of better plants for new buildings, as well as to impress upon the management of old plants the necessity of modernizing their equipment.



Art *in the* Electric Industry

by A. H. Markwart

Vice-President in Charge of Engineering
Pacific Gas & Electric Co.



BEAUTY ENHANCES esthetic enjoyment; good design attracts; bad design repels. These concepts were appreciated by the craftsman, who was an artist, and even in this day of machine manufacture and mass production, the value of attractiveness is not overlooked. Often the bare statement is made that art is useless but according to Victor Hugo, "the beautiful is as useful as the useful; more so, perhaps." Industry benefits by the practical application of this fact and the cry of "art for art's sake" has been silenced. "Art for industry's sake" is now the slogan of the alert manufacturer who looks to increased sales.

While it takes a philosopher to define art, the normal person can appreciate it despite a lack of understanding; he intuitively knows what he likes. The sagacious manufacturer is aware of this and is alive to the fact that most individuals are keenly sensitive to their surroundings and that they enjoy seeing and having things that please them. Competitors vie with each other in creating artistic distinctiveness to gain the consumer's favor. Well may it be said of the manufacturers, "Wherefore by their fruits ye shall know them."

There is a definite trend toward good design and color in the spirit of modern life and "there are significant evidences that the America of huge factories and of mass production is beginning to harness the attractive force of good design in team with the tractive power of her machinery."[1] Art and industry are no longer anomalous and most individuals will admit that there is a definite relation between art, in its beauty aspect, and general business, despite the complete unlikeness on the surface of the two. The classic truth that beauty arouses the interest and attention of the public is capitalized in a variety of ways and particularly by the manufacturers. Generally, business is aware of the tangible value, in terms of sales, of art in industry and it realizes more and more that it must take into account the insistent demand of the public for "good looks" in the thing it buys.

Art as a Stabilizer of Our Economic Structure

Modern industry has a capacity to produce in excess of man's normal physical and material needs; machinery of production can turn out things faster than man can destroy them. With this as a condition precedent, industry has adopted various policies to encourage consumption; installment plan selling, intended to lessen the economic pressure on the individual buyer, may be cited as one of these; similarly, the appeal to the

[1] "Getting in Step with Beauty," Robert W. De Forest, Review of Reviews, January, 1928.

emotions made by things of beauty is utilized to the utmost to overcome sales resistance and effect the spread of our flood of mass production. Industry recognizes that the development of the esthetic sense is indispensable if the economic operation of the production and consumption process is to be satisfactory. Consequently, industry has linked beauty with utility; machine-made articles, whether for utility or enjoyment, and even containers, are made pleasing to the eye to captivate man's interest and excite his cupidity. This stimulation of the acquisitive instinct inherent in man, is having its effect alike on the narrow utilitarian, through an awakening of artistic traits latent within him, and on

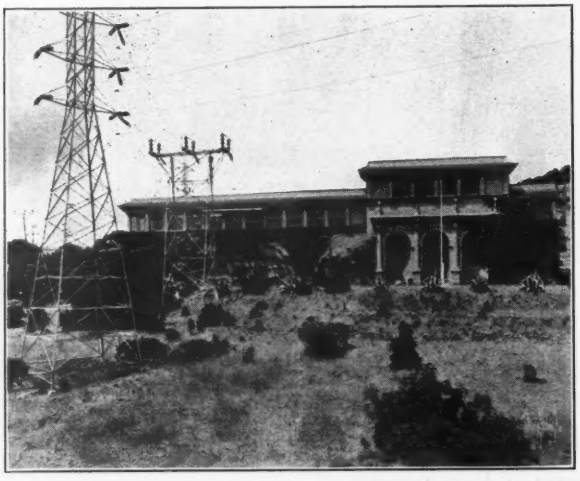


FIG. 1. CORDELIA SUBSTATION (1913) 60-KV. TERMINAL STATION

the cultured esthete through his susceptibility to artistic influence. What we seem to be doing is to accelerate the development of our social functions in the endeavor to keep them abreast of our capacity to produce. According to some observers of our modern economic processes, the whole course of action which industry takes to promote consumption is socially justified, because it is a means to the legitimate end of stabilizing our complex economic structure which rises from a foundation having the triangular contradiction of high wages for the worker, low unit cost for the consumer, and return for capital sufficient to insure its continued flow toward industry.

So far, we have been speculating entirely upon art as applied to the manufacturer's output, but there is that other phase of art in modern industry which is concerned with the factories in which the production is accomplished. Art enters here in the form of architecture. Architecture as distinguished from a mechanical or useful art is classified with sculpture, painting and music as a liberal or fine art. It would seem that a fine art could have no place in industry; however, there is abundant evidence to show that industry goes beyond the mechanical art of building its factories for utility, to the art of architecture for beauty. The several homes of the ubiquitous Shredded Wheat Biscuit are endeavors in fine art; even the pickle factory takes on the architect's art, if the newer establishments of the "57 Varieties" are artistic criteria.

Art in the Electric Utility Industry

Inasmuch as the electric utility industry sells something, which though appreciated cannot be seen, art for it has a different significance from that which attaches to general industry. It is a deeper one; its value is more subtle; and it must be manifested almost entirely in architecture.

While the electric utility industry, like any other, makes every legitimate endeavor to increase its volume of sales, its business policy is one of enlightened self-interest rather than pure commercial selfishness; the industry would seem to have a soul and, to a large degree, the spirit of service, rather than the competitive principle, actuates those engaged in it. They have come to regard their positions as ones of public trust. To them power has the quality of benignity which should be extended to all. With this in mind and with a view to mutual business prosperity, the electric utilities are striving to put electric service within economic reach of all and to distribute to the public all the benefits which the industry can bestow. Altogether there is probably no business into which is put a greater amount of zeal toward the consideration of the best interest of the consuming and investing public. The prime objec-

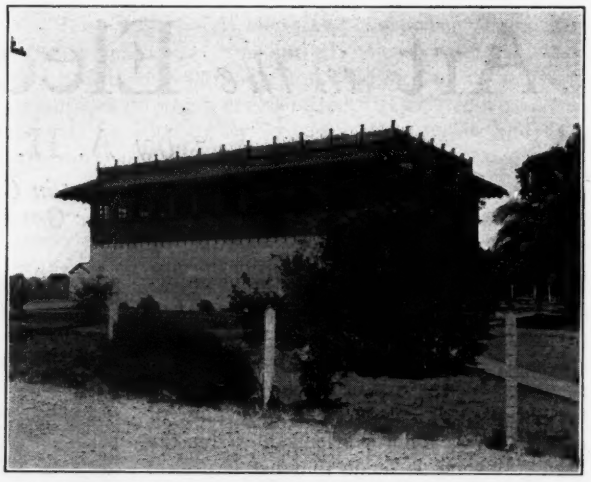


FIG. 2. WOODLAND SUBSTATION (1912) SMALL URBAN DISTRIBUTION SUBSTATION

tive of the electric utility industry is service at the lowest cost, consistent alike with continuous operation and sound expansion to meet the demands of present and future consumers, and with reasonable wages to capital. Albeit the industry has taken on an institutional character, capital expenditure for monumental building is, or should be, avoided because of its inspiration for, and suggestion of, extravagance contrary to the avowed purpose of service at the lowest cost; however, art in reason has a place in the structural elements of the electric utility industry, to the end that *nothing be constructed that is an affront to the public and subversive of good will.*

Effect of Artistic Treatment on Good Will

It is through art, using the word in its wider intellectual sense, that the individual may be made to see the soul in the body of things and it is through the appeal to his esthetic sense that his friendship may be

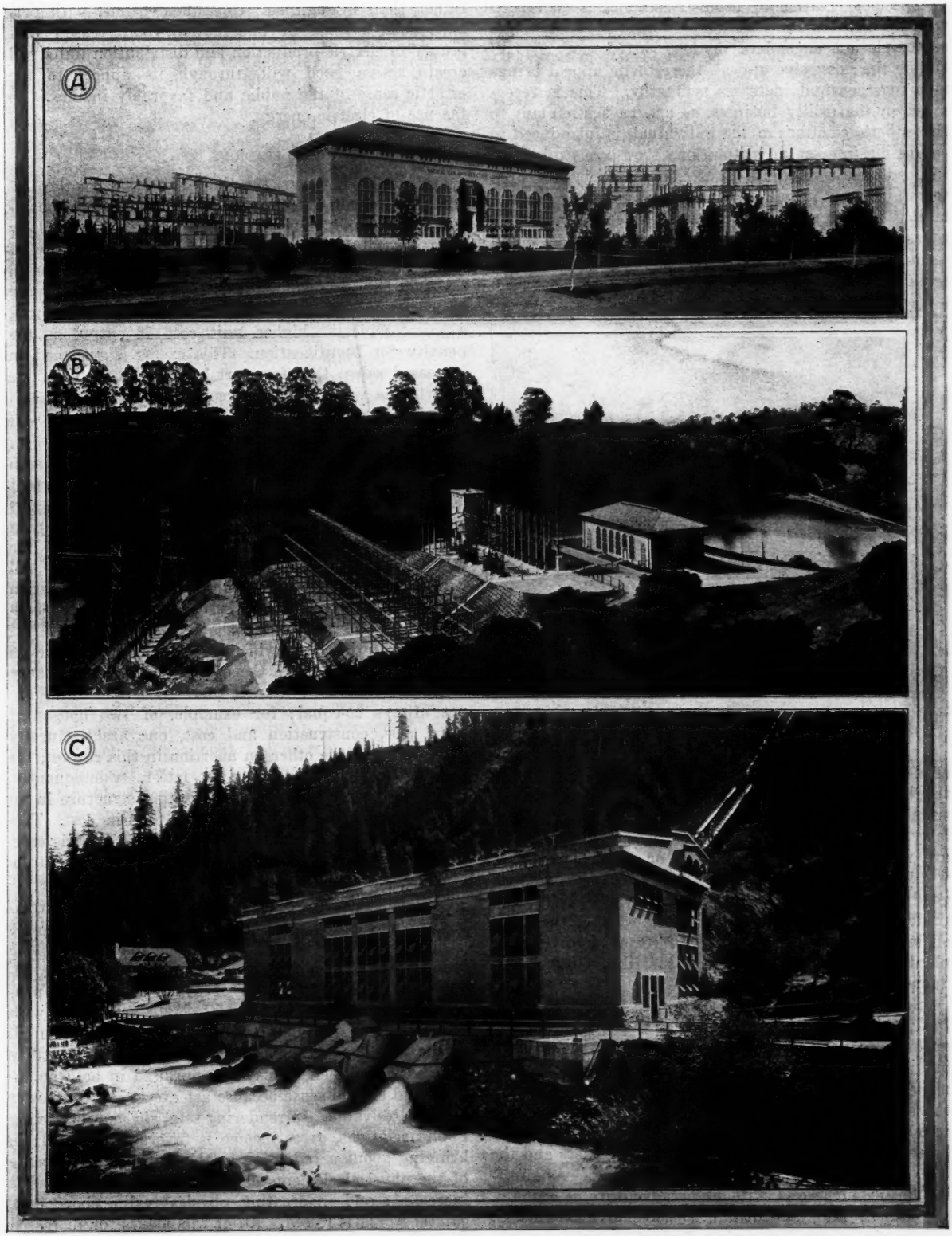


FIG. 3. VARIOUS STATIONS OF THE P. G. AND E. CO., SHOWING ARTISTIC TREATMENT

A. Vaca-Dixon substation (1923) 220,000 kv. terminal transforming and regulating station. B. Claremont substation (1923) 100,000 v. terminal substation. C. Drum Power House (1913) 55,000 kv-a. hydroelectric generating station.

secured. "Art," as we appreciate it in the electric utility industry, "is concerned with the more or less unconscious creation of beauty; esthetics is concerned with its discovery and contemplation. * * * Esthetic contemplation engenders neither hatred nor envy."[2] Unlike the possessive appeal, the esthetic appeal brings men together and increases sympathy. This is recognized in the utility business, so art, as a stimulant to the esthetic emotions of the individual, is introduced to secure his interest and attention; these are capitalized in good public relations. For example, if it is desired to obtain the good will, or at least the passive good will, of that portion of the public which concerns itself with zones of territory in which electrical structures would seem to be incongruous, the utility may quiet the objections raised by owners of property to the construction

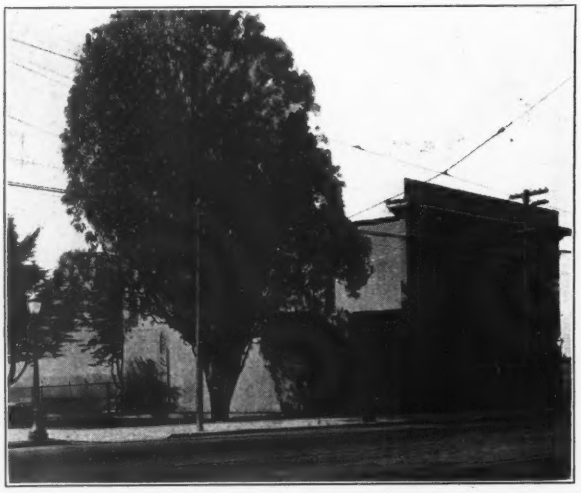


FIG. 4. SUBSTATION "L," SAN FRANCISCO (1927). FULL AUTOMATIC DISTRIBUTION STATION

of electric substations in residential sections, by making the buildings and grounds attractive respectively by suitable architectural and landscape treatment. Similarly, if steam plants and substation buildings which are to be erected in industrial or business districts within metropolitan areas are architecturally composed, good will is engendered since no injury is done to civic pride. It is even considered that the work of the artist on buildings and surroundings of remote hydroelectric plants, country substations and the like is not superfluous.

Some, but few, in the electric utility business go so far in their reasoning as to conclude that art and utility go hand in hand for the improvement of the business, but for many in this industry it is difficult to see the money value of art, except as it may appear through the sale of energy to consumers who would not have purchased such load building devices as ranges, space heaters, water heaters, refrigerators, electroliers and the like, unless such devices were "good looking." As affecting business, there is, without peradventure of a doubt, a relation, although distant, between "good looks" in electric energy consuming devices and the artistic, as related to the physical system which supplies the energy necessary to the operation of such devices. Nobody will dispute the statement that it is easier to sell an electric heater which is characterized by beauty rather than by ugliness; consequently one, with perhaps some stretch of imagination, may reason that beauty in electric production and distribution units will create active good will, through its appeal to the esthetic sense of the public and favorably incline it to the use of electric energy.

[2]"Dance of Life," Havelock Ellis.

Considerations of Cost

Generally, however, the thought is that, in the last analysis, the kilowatt-hour cost is raised where the instruments employed to produce and distribute electricity have art values, despite the fact that the increase, if any, in unit cost of output from a plant of good design and that from one which is artistically bad, could hardly be measured. But to pursue the argument, grant that a microscopically higher unit cost of output is the penalty for beautification. This excess is returned in increased sales; therefore, art has a cash value, if we hold to the view that it overcomes sales resistance and that increased gross income, rather than reduced expenses, makes for higher net income.

Although it may be difficult to measure the cash value of artistic effort, almost everyone will admit that a good-looking building, surrounded by well-kept gardens, will inspire the operators to good housekeeping and to better care for the machinery, than were the buildings and grounds esthetically unattractive. All will agree that this interest results in less depreciation expense to the utility and better service for the consumer.

Perhaps the best evidence that there is value in beauty will be found in the fact that a thing of beauty is often worth more than it cost. Cost and value are not always co-equal; for example, of two houses of equal size, construction and cost, one architecturally attractive and the other an abortion in this respect, the former has more value than the latter. Consequently, it may be reasoned that a good-looking structure in an electric utility system is worth more than its cost. This idea also carries over to public relations. In this case, it is the good will of the investing rather than the consuming public that is obtained by attractiveness.

While the utilities of the country introduce architecture and landscaping into the ensemble of power plants and substations, it is probable that this is done because those in immediate charge of engineering development during a period of expansion, have a penchant for that branch of philosophy concerned with esthetics, and an inclination, possibly temperamental, to the idea that art is beneficial to the electric utility business. This benefit may be appraised in both an income and capital sense because art exerts earning power and creates value. In rendering sales aid and improving public relations, gross income is favorably affected; in bringing about a reduction in the depreciation expense of the physical elements of the industry, net income is increased; and in creating physical value above cost, capital worth is raised. All of this makes for increased over-all value but admittedly such is difficult of segregation, therefore it must be lumped with the intangible values of the business like those of good will, going concern, water rights, et cetera.

The electric utility industry of California, like that of other sections of the country, gives consideration to beauty in its buildings and surroundings. The Pacific Gas and Electric Co., which possesses one of the largest regional interconnected systems of the country, is not wholly unsympathetic to the artistic urge, as evidenced by some of the illustrations which accompany this presentation. The engineers of this company, with economy in capital expenditure ever in mind, have endeavored to produce something which has an element of beauty at no increased cost over that which would be lacking in this quality. They have held consistently to the theory that from a given and necessary quantity of materials of construction it is possible to create something which is either distinctly ugly or fundamentally beautiful. Concrete, on account of its great adaptability to many uses and because it expresses the mass production technique of our times, is the material largely employed at the present time for power plants and substation buildings, in both city and country. The aim has been to produce building structures of simple lines, with a minimum of surface decoration, with dependence for architectural form upon the proportion of the mass and fenestration of the walls. The wall finish on buildings in the country is that which results with the removal of the concrete forms; plaster is employed in the cities.

Artistic Treatment of P. G. & E. Co. Structures

This company maintains an architectural bureau and on the more important projects consultation with outside architects is had. It is believed that most of the work of recent years is at least good and that none of it is distinctly bad. It has been felt that the buildings incorporated in a system comprising a number of structures, which are dependent upon one another for the fulfillment of a common mechanical function, should be made to express this relationship by a consistent architectural theme throughout the system. In following such a thought from year to year, however, there will be noticeable a most interesting transition in architecture between the old and the new, reflecting the changes in the technical field.

Cordelia Substation, one of the older switching and transforming centers on the Pacific Gas and Electric system, with its heavy transforming and switching equipment indoors, is characteristic of its time. The windows, governed by the entrance requirements of the high voltage lines, are large and brought immediately under the cornice. This technical requirement led to the use of the continuous window course, accomplishing all that is desirable in the way of light and ventilation, while providing at the same time for the entrance of the lines.

Woodland Substation, although a distribution structure of smaller dimensions, again shows the architectural treatment responding to technical requirements, with its high course of windows, certain of which are utilized for circuit inlets and outlets.

Turning to Vaca Dixon, a modern high tension switching, transforming and regulating substation, with its heavy electrical equipment placed in an outdoor switch yard, the large outlet windows are seen to have been superseded. The cornice decoration with its small round windows in groups of three, is, however, a rudimentary symbolism of the many circuits centering in the station. The fenestration expresses the high-storied, crane equipped space for the synchronous condensers, while the concrete mullions and bars, making up the large window units recalls the typical concrete cell structures of the interior equipment.

At Claremont Substation, the building proper is relatively less important in the scheme of things than where less apparatus is in view out-of-doors.

It has nevertheless been so treated as to make it the center interest architecturally, as it is the obvious center of control over the adjacent electrical equipment.

In still later construction, such as at Station "L," San Francisco, are found solid exterior walls without windows, responding to the unattended, fully-automatic equipment installed within and the underground disposition of the circuits leading to and from the station.

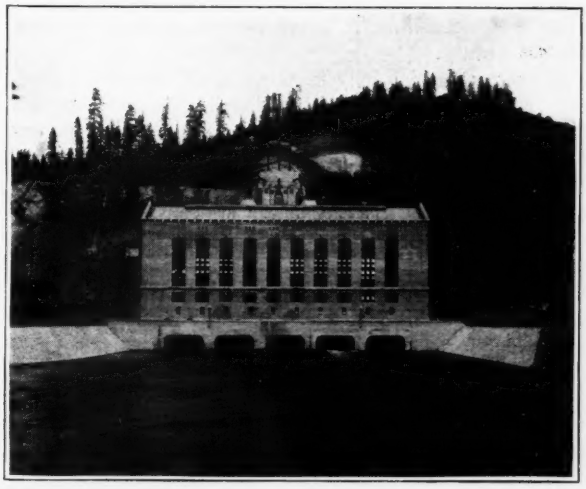


FIG. 5. PIT RIVER, NO. 3 POWER HOUSE (1925) 81,000 KV-A. HYDROELECTRIC GENERATING STATION

The solid walls are also prompted by the necessity for sound-proofing in certain locations.

The same architectural transition in step with technical advances is to be noted in the treatment of the hydroelectric plants. The outlet feature on the Drum Power House was necessary for the outgoing high-tension circuits from the indoor transformer banks. The course of large windows in Halsey Power House, shown at the head of this article, likewise reflects the heavy indoor equipment.

In the more recent Pit River No. 3 Power House with outdoor transformers and switches, the outlet windows are absent and the entire treatment varied. This building is of concrete with the surface left in the rough, without cornice projections, dependence being placed on proportion and scale, both in general line and fenestration, together with its setting, for its successful treatment and satisfying effect.

When industry has successfully emerged from the pioneer or development stage, it becomes organized, orderly and stable; its physical elements usually become relatively permanent and characteristic; and often art, either good or bad, using the word in its fine arts sense, is evolved without much thought to this end. With economic maturity, bad art if present is often swept away and when neither good nor bad has been created

during the industrial adolescence, art is introduced. While, if we consider the matter philosophically, this does not product art, using the word in its truest sense, it caters to the insistent demand for beauty and satisfies the esthetic instinct in man.

The Inherent Beauty of Industrial Structures

While art may result from creative impulse, as may be inferred, it is often the unconscious by-product of utilitarian production. Many things of utility which have been produced, have in them the elements of art, although the creative impulse of the artist was not present. We think the steel tower transmission line falls into this category and perhaps Pennell would find beauty in it as he did in the bridges of New York and the smokestacks of Pittsburgh. Admittedly this structure, like the grain elevator and the pyramidal of "stepped-in" skyscraper, is a frank expression of purpose, and according to some canons of taste it may possess beauty.

Perhaps the day may come when all electrical operation will be conducted out-of-doors. Progress in this direction began with transmission and has been extended quite generally to transformation and switching. We now have instances, rare it is true, of outdoor generation both in hydro and steam stations, and the outdoor installation of synchronous condensers in an atmosphere of hydrogen. It is conceivable that still further advance in the electrical art will confirm this practice universally. If this comes, no longer will there be a place for art in the electric utility industry as it is expressed in the architecture of the buildings that now house machinery; consequently art, if it is to be had without buildings, may find expression only in the form, proportion of mass, and color of the machinery and frame work employed to render electrical service.

Since, even with this advance toward outdoor equipment, in all probability there always will be some electrical apparatus that must be housed, architecture may be said to be permanently placed in the electric utility industry. This being the case, the writer opines that the time is ripe for an architectural style that has a peculiar application to electricity. With some exceptions, about all that has been done thus far is to house electrical apparatus with the purpose of concealing rather than expressing electricity. In a recent issue of Power Plant Engineering, there appeared a discussion of the use of beauty in power plant and substation construction. Of a certain substation it was said, "So dignified does the building appear that it has often been mistaken for a branch of the public library or a branch of one of Atlanta's larger banks."[3] While beautification in this case is to be commended, it is a sad commentary on the genius or creativeness of the engineers in the electric utility industry that a substation and a public library are not distinguishable. One could never mistake an American grain elevator for a bank nor a modern industrial building for a city hall, yet both have architectural treatments expressive of uses.

Engineering structures can be things of beauty and can contribute to a new style of architecture. We may console ourselves with the fact that there are units in the physical systems of electrical utilities which reveal that engineers have a sense of beauty and at times they have been unconscious contributors to art. There are many engineering structures in the way of power stations, towers, outdoor bus structures and even complements of electrical machinery that conform to the rules of beauty which govern the two fine arts, architecture and sculpture. In this connection, a tribute was paid to engineering and the electric utility industry, by Professor G. H. Edgell of the Department of Fine Arts and of the Faculty of Architecture of Harvard University. Referring in a recent book to the Cahokia steam station, he says, "Built up from the river in terraces of steel and ferro-concrete, vertically buttressed with great concrete strips that increase in scale with every block, pierced with great verticals of glass and crowned with four pairs of enormous chimneys, it would be difficult to find a more impressive structure. Call it engineering if you will. Gustave Doré would have reveled in it and the American who, on account of its purely utilitarian purpose, denies it a place in the great architecture of his country, is a man of small taste and less vision. * * * It suggests the titanic forces of nature controlled by the genius of man."

Style Should Be Emblematical

Beauty will be had in the electrical industry if sound architecture is employed in its buildings; and where appropriate, color and landscaping will enhance their beauty. But any architecture, to be highly successful, must be modern in its expression of the needs, standards and processes of its times. This is the view of the philosophizing architect. For instance, he says that our commercial and industrial building is on the whole the most significant part of American architecture today. This is because the utility of these buildings has not been compromised by obsolete and irrelevant ideas of structure and esthetics. In the electric utility industry, we must likewise satisfy basic utility requirements. If the mechanical art of electrical production and distribution does not unconsciously produce an architectural style, one may be created for it. If it is, the architecture must be in synchronism with the outlook of our own times and the technique of electrical practice and especially it should depict some essential or universal quality of electricity and express its diverse manifestations, if this can be done through the medium of architecture. At any rate, the architecture must not follow the traditional thing, nor should architectural styles which were used to symbolize something else be employed in our case. It is obvious that we should discontinue the practice of merely decorating or coating the engineering structure of the electric utility industry with architectural ornament and detail, of styles which grew out of the needs of the past. While the age-old principles of simplicity, symmetry, harmony and proportion are in order in the development of an architectural style for such structures, replicas of Greek temples are not. The style should be emblematical and have the fundamental quality of futurity instead of that of retrospection. If it becomes all that we think it should and if it is characterized by truth and sincerity, the electric industry will be twice blessed. Not only will those general benefits which logically accrue with the correct development of any art flow to the industry but also those peculiar benefits which the industry sought by merely applying art more or less superficially, will be realized.

[3] "Beautification of Power Plants and Substations," P. S. Arkwright, "Power Plant Engineering," June 1, 1928.

Electricity---What It Is and How It Acts*

PART XVIII. HOW MUCH ELECTRICITY IS THERE IN AN ELECTRON? OVER SIX BILLION BILLIONS OF THEM PER SECOND NEEDED TO MAKE ONE AMPERE. BY A. W. KRAMER

BEFORE LEAVING our discussion of Millikan's discovery of the electron started in the previous article, it will be of interest briefly to consider the work which came as the immediate consequence of his balanced drop experiments. For it must be understood that these experiments are of tremendous importance not only in the field of electrical research but in all other sciences as well. So far, in describing Millikan's work, we have but shown that electricity is atomic—that it consists of particles, just as matter is known to consist of particles, the atoms and molecules. What was of even greater importance to Millikan, however, was to determine the exact value of the electric charge carried by the electron.

The way for doing this seemed clear. The balanced drop experiment showed that with a given droplet in a given field, there was a different rate of speed for each charge that the droplet carried. To convert these speed units into electrical terms, it was necessary only to know how, in a given medium (air in this case) the speed due to the charge on a drop was related to the size of the drop.

This relation between the velocity of the drop and its size, it was known could be determined by the aid of Stokes law. In applying this law, however, Millikan found that for extremely small droplets, Stokes law was inaccurate. So steps had to be taken to determine just where, as the size of a large droplet was reduced, Stokes' law becomes invalid, and what measures must be applied to insure correct results when it was used with small droplets.

How this was accomplished,—the care which was exercised in insuring accuracy, the painstaking work done in determining the exact coefficient of the viscosity of air (which was a factor to be known) is a story of absorbing interest and the reader who wishes to know the details is referred to Millikan's book, The Electron.[1] An incidental part of this work was the weighing of the droplet. It was apparent that if the weight of the oil drop was known, the charge on the drop could be easily determined. Under gravity, the velocity of the drop is proportional to its weight but in an electric field, the velocity is proportional to the charge which it carries. Since both of these velocities could be measured directly, it was evident that the weight or the charge could be determined if either one of these factors were known.

WEIGHING TO THE TEN BILLIONTH OF A MILLIGRAM

The charge was found with the aid of Stokes' law. What was done, therefore, was simply to charge a drop with a given number of electrons and then pull it up against gravity by the electric field or it was kept stationary and balanced against gravity in the manner already described. In this way, Millikan provided an electric balance in place of a mechanical one, so sensitive that it would weigh accurately and easily to *one ten billionth of a milligram!* A milligram is less than 1/28,000 of an ounce.

Such an electric balance makes it possible to weigh bodies accurately, so small as not to be visible to the naked eye. "For," using Millikan's own words, "it is only necessary to float such a body in the air, render it visible by reflected light in an ultra microscope arrangement of the sort we were using, charge it electrically by the capture of ions, count the number of electrons on it and then vary the potential applied to the condenser plates, or the charge on the body until its weight is just balanced by the upward pull of the field. The weight of the body is then equal to the product of the known charge by the strength of the field."

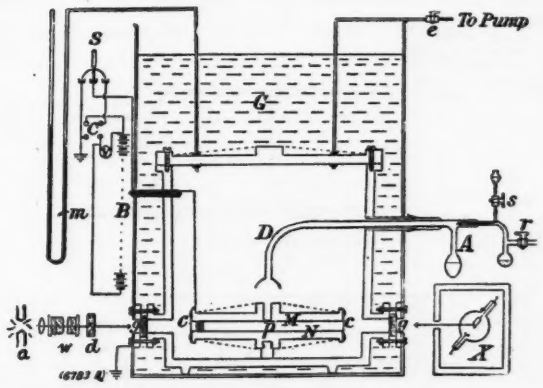


FIG. 1. FINAL SET UP USED IN MILLIKAN'S OIL DROP EXPERIMENT

In this apparatus the oil drop is suspended between the plates M and N. D, is an air tight container into which the oil spray is introduced by atomizer A. To prevent temperature changes, the entire equipment is placed in engine oil in container G. An arc light at a, illuminates the drop through window g and c. At X is an x-ray tube for ionizing the atmosphere between the plates.

DETAILS OF FINAL APPARATUS

Millikan's final experiments were conducted with great refinement. Figure 1 shows the set-up of the apparatus used in the later experiments. The condenser plates between which the droplets were observed are shown at M, N, mounted at the bottom of a heavy brass vessel D. In these experiments, it was necessary to observe the action of the drop under varying pressures, so a connection was made to exhaust and compression pumps so that the pressure in D could be varied. The pressure was measured by a mercury manometer m. At the left at a is an arc lamp for illuminating the droplet through windows g and c. It is evident that, for the success of this experiment, the air between the plates must be completely stagnant. To insure this, temperature variations must be eliminated, so the entire vessel, D was placed in a constant temperature bath of engine oil which permitted of a temperature variation of not more than 0.002 deg. C. To absorb the heat rays from the arc lamp, the rays

*All rights reserved.
[1]The University of Chicago Press.

were passed first through a water cell 80 cm. long and then through a cupric chloride cell. The atomizer for introducing the oil spray is shown at A. An x-ray tube is shown at the right for ionizing the atmosphere between the plates.

This arrangement, except for the refinements, it will be noted is virtually the same as that shown in the preceding article. Extreme accuracy was observed in every detail. The condenser plates for instance had surfaces which were polished optically and made flat to within two wave lengths of sodium light. The voltage on the plates was determined after each reading in terms of a Weston standard cell and was accurate to one part in 3000.

Let us transport ourselves to the Ryerson laboratory and in our imagination picture what we see in the eyepiece of the microscope. The tiny oil droplet, invisible

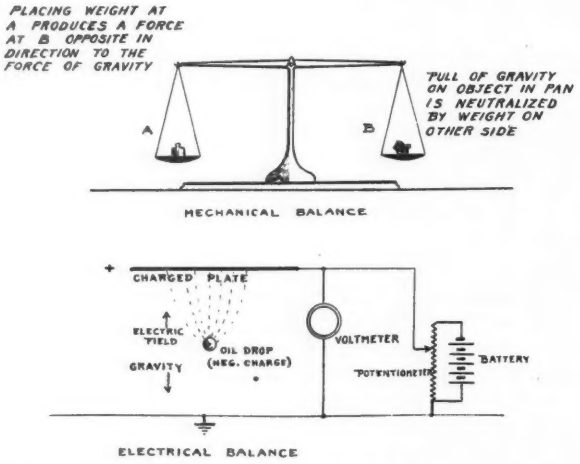


FIG. 2. COMPARISON BETWEEN MECHANICAL AND ELECTRICAL BALANCE

Above is shown a simple mechanical balance. In this device the pull of gravity on the object to be weighed in the right hand pan is exactly balanced by the upward pull due to the weight in the left hand pan. The beam pivoted at the center serves to reverse the direction of force. In the lower diagram is shown an electrical balance. Here the potential of the battery is the "weight" used to balance the gravitational pull on the drop.

to the naked eye, blazes forth, a brilliant star against a dark background. As we put our eye to the eyepiece, the drop is rising slowly. We watch it carefully and when it touches the upper cross hair in the field of the microscope we suddenly throw off the field on the plates by means of the switch S. Immediately, the droplet begins to fall and we watch it until it touches the lower cross hair when we again charge the plates by throwing the switch. The drop starts upward at once but this time it rises much faster than before. Evidently, on its downward journey, it captured an ion carrying a negative charge. (We assume the upper plate to carry a positive charge.) We watch the drop closely and when it again touches the upper hair line, the field is cut off and the time recorded on the chronograph. On the next upward journey, it rises still faster showing the capture of still another negative ion but as the droplet reaches the center of the space between the plates it suddenly slows down again. In this case, it has captured a positive ion, thus neutralizing some of the negative charge which it already carried.

The whole thing is marvelously simple and yet, as we see this brilliant star suddenly accelerate or decelerate as it captures or loses charges, it seems a bit uncanny. We are observing the direct effect of the smallest "thing" in the universe!

By carefully noting the same droplet for a long time and noting the speed each time, we see at once the very simple relation that exists between the speeds. Knowing the law connecting the speed of droplet, its size, and the charge, the charge of the single electron is easily determined.

The Numerical Value of the Electron's Charge

Millikan's work extended over a period of years and thousands of observations were made but at no time was a variation observed which could not be accounted for and explained. When all was done and the final calculations were made, the absolute value of the charge of the electron was found to be

$$4.774 \times 10^{-10}$$ absolute electrostatic units

Now, what does this number mean? Why did Millikan and others spend years upon years, working in laboratories, merely to bring forth this number?

Before explaining it, let us say, here, that this number 4.774×10^{-10} is the most fundamental of all physical or chemical constants. It expresses in terms with which we are familiar, the value, not only of the smallest possible electric charge but also, in a way, the smallest particle of matter.

It represents a quantity of electricity—the smallest quantity of electricity which it is possible to have.

Systems of Units

Ordinarily, where we measure electricity we use the ampere or the watt and when we measure its pressure or potential we use the volt. These are, of course, arbitrary units, selected because of their fitness in measuring such quantities of electricity as we deal with. No system of measures is of value, however, unless the units on which it is based can be reproduced. Thus, the meter, which is the standard unit of length in the metric system, was selected as a length equal to the ten millionth part of the northern quadrant of the earth. In this same system, the unit of mass is derived from the unit of length and is the gram, which is the mass of a cubic centimeter of water at 0 deg. Centigrade.

A number of systems of fundamental units have been proposed from time to time, some of which have been used to a greater or less extent. The system on which our electrical units are based is the centimeter-gram-second system, usually called the CGS system and based on the centimeter, the gram and the mean solar second.

In this system, the unit of electric current is the absampere. This represents an amount of current the value of which is such that when one centimeter length of the circuit is bent into an arc of one centimeter radius, the current in it will exert a force of one dyne on a magnet pole of unit strength placed at the center of the arc. The dyne referred to in this definition is the unit of force in the C.G.S. system. This represents the force which after acting on a free gram during 1 sec. creates in that mass a velocity of 1 cm. per sec. Thus it is seen that a unit of current can be derived from the fundamental units of length, mass and time.

It is expressed in terms of the magnetic field it produces.

For practical purposes, the C.G.S. units of electricity and magnetism are either too small or too large, so a system of practical units has been developed. The ampere is our practical unit of current and is one-tenth of the absampere.

From the ampere, we get our practical unit of electric quantity. This is the coulomb, and it is defined as the quantity of electricity to be conveyed by one ampere in one sec. The ampere, in other words, represents the transfer of a coulomb per sec. The coulomb represents a unit of quantity just as a gallon in hydraulics represents a unit of quantity.

The Electron in Terms of the Coulomb

Now, the charge carried by the electron also represents a definite amount of electricity—it in itself is a unit of quantity. How then, does the charge on the electron, which we have said is 4.774×10^{-10} electrostatic units, compare with the coulomb?

The coulomb is the practical unit of quantity. The absolute unit of quantity in the C.G.S. system is very much smaller than the coulomb, millions of times smaller in fact. Its value is expressed as 3.3×10^{-10} coulomb.

To find out, therefore, just how the electron compares with the coulomb, we multiply

$$\begin{array}{rl} & 4.774 \times 10^{-10} \\ \text{by} & 3.333 \times 10^{-10} \\ \text{and obtain} & \overline{1.591 \times 10^{-19}} \end{array}$$

In other words, the value of the charge on the electron is $\frac{1.591}{10{,}000{,}000{,}000{,}000{,}000{,}000}$ of a coulomb, or there are 6,280,000,000,000,000,000 electrons in a coulomb.

Since an ampere is a coulomb per second, it is evident that a current of one ampere in an electric circuit means simply that six billion, billion electrons pass a given point in the circuit every second.

Numbers such as these mean very little to the ordinary mind. Whether the above strings of figures have 15 ciphers back of the integer or 19 of them, is of little significance to us. We can form no mental picture of 6 billion, billion electrons simply because such numbers are entirely beyond our experience. The best we can do is to compare them with experiences with which we are familiar.

Suppose, for instance, we set out to count the electrons which entered a condenser during one second with a current of one ampere; that is, the number of electrons in one coulomb. To facilitate the process, we devise a counting machine which counts one thousand electrons per second. To count the 6 billion billion electrons which have entered the condenser in that one second would require that this counting machine count at the rate of 1000 per sec., uninterruptedly for 190 million years! This, perhaps, is equally inconceivable, still it is interesting and provides us with a little food for thought.

So, in the electron, despite the fact that we have several systems of units, we have the natural unit of electricity, one that has no relation with anything else. It is more than that, however; it is, without doubt, the most fundamental unit in the universe, for, as has been explained in previous articles of this series, all matter is made up of these electrons. Millikan experimented, for many years, with all sizes of drops of various materials and in various gases, but in no case has there ever been a variation from the absolute quantity 4.774×10^{-10} electrostatic units for the charge. No matter from what material the electron is obtained or in what manner, it is always the same.

The science of electricity was already well developed when the electron was discovered and the laws of its action determined. If the value of the electron's charge had been known earlier, it is probable that today we should have an entirely different system of practical units based directly on the electron. It is unfortunate that this is not the case. We have already discussed[2] the discrepancy between the known direction of flow of electrons and our common conception of the direction

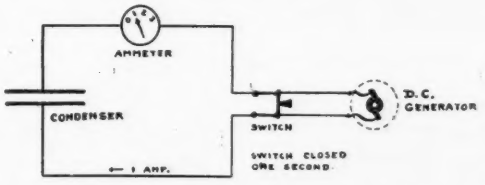


FIG. 3. DIAGRAM TO SHOW VALUE OF A COULOMB
If the switch in this circuit is closed for just one second, and if during that second, a steady current of one ampere flows into the condenser, there will, at the end of that second be stored up in the condenser exactly, one coulomb of electricity. This means that over 6 billion billion electrons have entered the condenser.

of current in a circuit. The electron flow we know is directly opposite to the direction in which we say the current flows and as a consequence we are compelled to make awkward compromises. There is no such thing as a flow of electrons against the current. The current is from negative to positive and *not* from positive to negative as we are taught.

[2]Part VIII, Sept. 1, 1928 issue, page 934.

Des Moines, Iowa, Electric Light Co. will spend $375,000 on improvements and extensions in 1929, C. A. Leland, Jr., vice-president and general manager of the company, recently announced. The program provides for a 44,000-v. line reaching half way around the city, relegating the present 13,000-v. lines to feeders, any one of which would be sufficient for the city, while the main line will be sufficiently large for distribution of power to a community of 300,000. New sub-stations at Valley Junction and South Des Moines and $150,000 expenditure upon extension of farm service lines, equal to double the amount spent last year, are also on the program.

Central Maine Power Co., Augusta, Maine, has made plans for a proposed hydroelectric plant on the Kennebec River near Bingham, where power site was acquired a number of months ago. The generating plant will be designed for a capacity of about 60,000 hp. and it is understood that the project is scheduled for completion in 1931. The company is operated by the National Electric Power Co., New York City.

Homecoming for Kilowatt-Hours

SOME ASPECTS OF GROWTH AND FUTURE POSSIBILITIES OF ELECTRIC POWER UTILIZATION BY DOMESTIC CUSTOMERS. BY H. T. EAST*

REVIEW OF THE light and power industry's growth and development from any angle cannot fail to impress one. The world's first central station company began operation less than 50 yr. ago. There followed a period of slow progress, during which the industry competed with the gas industry for the lighting business but it was not until the beginning of the Twentieth Century that the development which has placed it in the foremost rank of the nation's industries really began.

EARLY GROWTH WAS ESSENTIALLY IN HOUSE LIGHTING

Benefits of this new agency, electricity, were so apparent that customers everywhere clamored to be served. Because its principal application was in the form of light, it naturally followed that a large percentage of the customers were residential. For years the problem was simply to connect and supply additional homes and this effort produced an annual increase in new business sufficient to provide an ever increasing growth with resultant mounting revenue. When we consider the fact that fully 85 per cent of the homes within reasonable reach of existing lines are already receiving service, it is clear that future growth must depend more and more upon increased kilowatt-hour consumption by existing customers rather than upon new customers.

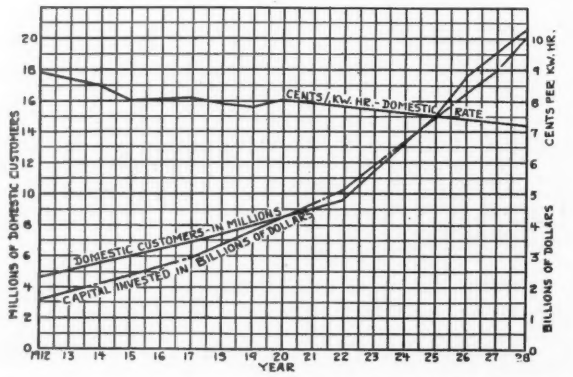

MILLIONS OF DOMESTIC CUSTOMERS
CENTS PER KW. HR.
BILLIONS OF DOLLARS
CENTS/KW. HR. - DOMESTIC RATE
DOMESTIC CUSTOMERS - IN MILLIONS
CAPITAL INVESTED IN - BILLIONS OF DOLLARS
YEAR
'12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

FIG. 1. RATES HAVE STEADILY DECREASED WHILE CUSTOMERS AND INVESTED CAPITAL HAVE INCREASED RAPIDLY SINCE 1922

Growth of the central station business to its present position as one of the nation's largest industries has come within the span of a single generation. The reasons for this phenomenal growth were largely external and the problem of the industry has been merely that of finding a way to supply the demand. Engineering and financial problems occupied the attention of the industry until comparatively recent years, when the demand for increased use of the huge sums invested began to exert itself. The problems confronting the industry, simple at first, but growing as the business developed, have always been solved, although changing conditions, both within and without, made this no easy task.

So far as the domestic power market is concerned, the problem today appears to be that of obtaining increased revenue without a proportional increase in the capital invested and without requiring the customers to rewire their premises in order to accommodate the increased load. This problem is of such magnitude and importance that much careful study and analysis must necessarily precede its solution.

EXTENSION PLANS SHOULD CONSIDER FUTURE PROFIT

Because of the rapid increase in new capital required, (this figure for the year 1929 is estimated at 854 millions of dollars for the United States alone) the directive heads of the light and power industry realize the need for increased sales efforts to provide the revenue which will warrant such annual increases in investment. Those in charge of the new business departments have been confronted with the task of increasing sales of energy to meet this demand.

In their zeal to increase the paying load, much new business of various kinds has been developed. In too many instances, the success of these efforts has been measured in kilowatts connected or dollars of new revenue instead of present or probable future profit, with the result that load factors were lowered and extensions of outside plant made that were not always desirable. New business has too often meant new lines and facilities which required still more capital.

Another method of increasing kilowatt-hour sales and one which is now in almost general use is the merchandising of appliances and other current consuming equipment by the utility company. This policy is fundamentally correct, since kilowatt-hours can be used only in current consuming devices, but concentration on the volume of such sales, without thought as to the resultant load factor and the suitableness of the added load from a profit standpoint may lead to trouble. Then, too, appliance sales are attended by servicing problems, which in many instances have increased operating expenses to a point where they absorb the profits from energy sold through the appliances.

SERVICE COSTS AND OVERHEAD ARE IMPORTANT FACTORS

Instances are recorded where the servicing cost on certain types of domestic appliances equals the total annual revenue which these appliances produce. The time to analyze these costs is before the selling effort and not afterward, since the obligation to stand back of merchandise sold is, in general, a continuing one.

Early rural extensions provide another example of blind sales efforts. In many instances, no analysis of rates or the costs of furnishing such service was made.

*Chairman, Customer Relations Committee, Commercial Section, N. E. L. A.

The effect of the mistaken policies was not felt immediately, because of the relatively small number of such customers as compared with the total. When the situation was analyzed, it was found that, either a higher rate or special financing plan was necessary, if the business was to stand on its own feet. Changes were found necessary. Usually the customers affected considered the changes an injustice, because they did not understand the reasons prompting them. Ill-will created in this manner has serious after effects.

Construction and Operation Are Vital Points in Sales Plans

One possible cause for the mistakes outlined was the lack of proper and thorough coöperation between the various departments of operating companies. This is most likely to be true of the larger organizations. The sales efforts may not be coördinated with operating or construction efforts or at least this coöperation does not occur early enough to avoid errors. Every sales plan or activity of major importance has its operating or construction aspects as well as a bearing upon the general policy of the company. All must aid in analyzing the major problems and in planning for the future, if satisfactory results are to be expected.

Domestic Power Market Is Promising Field

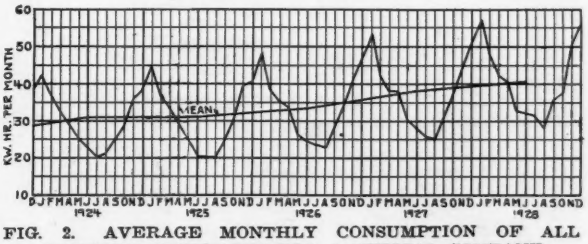
Any program to increase output or stimulate the general growth of the business must necessarily include the domestic power market. Why is this so? The latest available statistics show that over 19 million, or more than 80 per cent, of customers served today in the United States are in the residential class. Although only about 25 per cent of total sales in kilowatt-hours in 1928 were to domestic customers, these sales produced approximately 60 per cent of the total revenue (figures from Electrical World approximated). Here then is the greatest field for development in load which will bring in revenue and, at the same time, contribute most to human welfare by improving living conditions and directly aiding the greatest number of individuals.

If this potential increase in demand is to be profitable to the central station company, it must be diversified. Diversification may be brought about either by rate structures or by the development of current consuming devices for the home which will, by their very nature, improve the load factor. The growth must not entail a proportionate increase in the capital invested and should not require any material increase in capacity of interior wiring, which would mean increased customer capital investment.

To be effective, the increased consumption must be of a type that has service value to the users, who should not be expected to increase their usage greatly until it can be proved that they will benefit thereby. The service must always be worth more than it costs them. Applications of this nature may take the form of power devices, water heating or house heating. It will be no easy problem to develop devices or policies to fill the need but greater problems confronting the industry have been successfully solved and there is no reason to believe that this one is impossible of solution.

Trend of electric rates has generally been downward, as shown in Fig. 1. The necessity for lower rates before a marked increase in use of the commodity could be expected was early recognized. At first, production costs kept rates up and the industry set to work to reduce production costs. First came the high efficiency steam turbine; then a gradual increase in the size of the units; next followed the mammoth superpower stations, generating electrical energy for transmittal over wide areas through a network of lines interconnected with other huge stations. This evolution of the modern power station made possible lower power costs, which, in turn, permitted marked reduction in rates. Further reductions were made possible by other economies in operation and organization.

Today, approximately 60 per cent of the new light and power company investment is made outside the walls of the generating station and the ratio is increasing each year. Further reduction in production costs may be expected but this ratio and its trend clearly indicate that future reductions of substantial character can be brought about only by reducing costs in transmission or distribution or through a greater use of existing facilities. Until this problem receives the


60
50
40
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KW. HR. PER MONTH
MEANS
D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
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FIG. 2. AVERAGE MONTHLY CONSUMPTION OF ALL DOMESTIC CUSTOMERS FOR A TYPICAL COMPANY

thought and study already given the reduction of production costs, a continuance of material rate reductions can hardly be expected.

Usually, the engineering department is too much engrossed in solving its particular problems to give thorough study to future conditions which may be introduced by sales efforts in the planning. To it must fall the task of reducing distribution and transmission costs. It must meet the growing demands for more continuous service, which the more general use of equipment and appliances requiring an uninterrupted supply of electric current requires. It must work out cheaper underground installation costs or work to combat the increasing demands for underground installations to replace eixsting adequate overhead plant. It should aid in working out any large scale sales plan, so as to be able to meet the situation which may result.

Rates Should Be Formulated to Meet Future Growth

Rate structures have also been constantly undergoing changes to meet the new order of things. At first, flat rates filled the need. These soon became inadequate and gave way to metered rates. Changing conditions made a straight rate per kilowatt-hour unsatisfactory and other rates were formulated. The industry today has many complicated rate structures, some of which have been outgrown, and there is in

some quarters an apparent reluctance to adjust them to meet the changing conditions and to simplify them for public understanding. Examples are high minimum rates or schedules, based upon the number of outlets, in an era when many convenience outlets are advocated for customers.

In many instances, a change of rates to adjust differences existing between various classes of service will also be found desirable. The domestic rate has always been the higher rate and rightly so because of the distribution costs involved. But the domestic user deserves full consideration in rate readjustments. In any

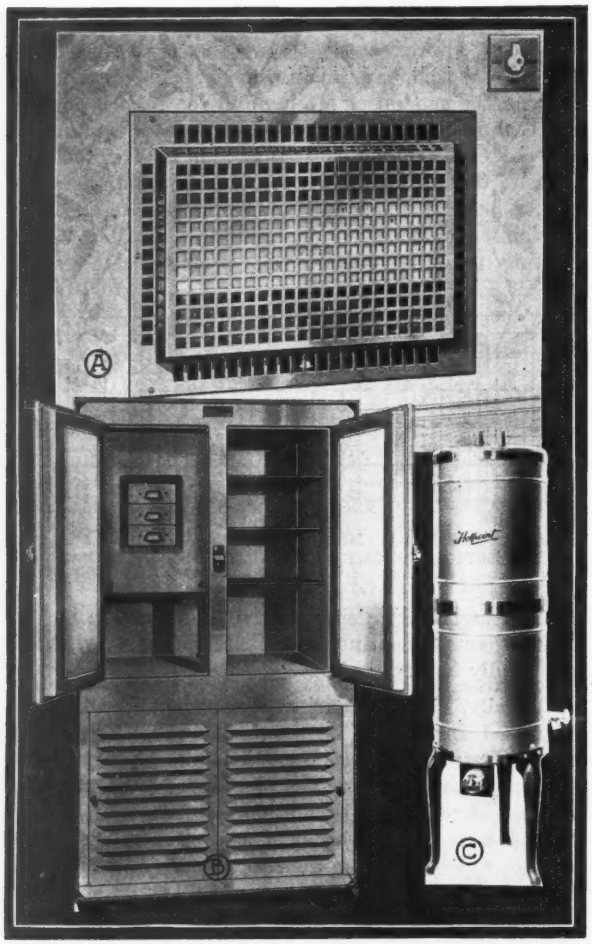


FIG. 3. REFRIGERATORS, SPACE HEATERS AND HOT WATER HEATERS OFFER AN UNDEVELOPED FIELD AS LOAD BUILDERS WHICH IMPROVE THE LOAD FACTOR

event, the rate itself and the rate structure will have an important bearing on the future domestic power market. Some economists still claim that the past growth of the industry was due to constantly lowering rates, instead of lowered rates being due to the growth of the industry which is indicated in Fig. 2.

The value of good-will has long been recognized in the industry and considerable attention has been given public relations at meetings of the industry. Too often there was too much talk and too little action taken to achieve the objective, which all recognized as necessary for continued prosperity. Good-will has been defined in various ways. One definition is that appearing in a Supreme Court decision, wherein it was characterized as "The disposition of pleased customers to return to the place where they were well treated."

Good-will may be gained by improving the quality of service, by reducing its cost to the consumer, by simplification of rate structures, by educating the customer to the company's problems, by fair and considerate handling of customer contacts and by informing the public of the actual benefits which will accrue to those making fuller use of the service offered. But what has this to do with the tomorrow's domestic power market?

It is true that good-will has a decided effect upon the results of sales efforts, since satisfied customers with confidence in the company will offer much less sales resistance than customers who feel otherwise. A satisfactory customer relationship may, therefore, be considered a necessary prelude to successful sales campaigns in the future. The time to build good-will is now; that is, the field must be prepared in advance so that good-will efforts which result in satisfying customers at present will pave the way for successful sales in the future, along with other recognized benefits.

These Things Are Vital to Growth

If the subject has been correctly analyzed, the future development of the electricity distributing company depends, to no small extent, upon the controlled growth of service utilized in the home. This is the widest market and one best able to pay the rates required. It would be futile to attempt to bring about the desired result without selling the service on a basis of honest and real value to the user.

Thus, the need becomes one of devising new utilization methods, of increased and concentrated sales efforts, of working out lower distribution costs to permit lower rates, of an equitable rate distribution employing simplified schedules and of intensive efforts to build goodwill which will insure the success of all such plans. The satisfactory carrying out of such a program will demand the coördinated efforts of the best minds in all departments. Once achieved, the resultant benefit will accrue to the industry as well as to the public at large.

An electric motor which has seen 36 yr. of regular service has been discovered by the Brooklyn Edison Co. in the Williamsburg section of Brooklyn. It has operated the machinery in the woodworking shop of Hiram A. Akerly, carpenter and builder, at 173 Berry St., since 1893. It is a 15-hp. direct current machine manufactured by the Electron Manufacturing Co. of Springfield, Mass., and was designed to operate at 230 v. The motor is marked "Perret's Patent" and bears the dates May 14, 1889 and July 15, 1890. According to Mr. Akerly, who has been in business at about his present location since 1879, the motor was installed at the time the Grand St. electric line was laid by the Municipal Electric Light Co., one of the original predecessors of the Brooklyn Edison Co. The motor, still in good condition, is now being replaced by a modern alternating current machine.

Design and Operation of Generator Air Coolers

PART. I. PRINCIPLES OF OPERATION, CLASSIFICATION OF TYPES OF COOLERS AND ADVANTAGES OF EACH. BY E. WAINWRIGHT JOHNSTON*

WHEN ENERGY is changed from one form to another, certain unavoidable losses occur. The electric generator, in converting mechanical energy into electrical energy, is no exception to this rule and, although large units have an efficiency of well over 95 per cent, there are internal losses that generate heat. Heat thus generated is not only detrimental to the installation but decreases the output of a given machine.

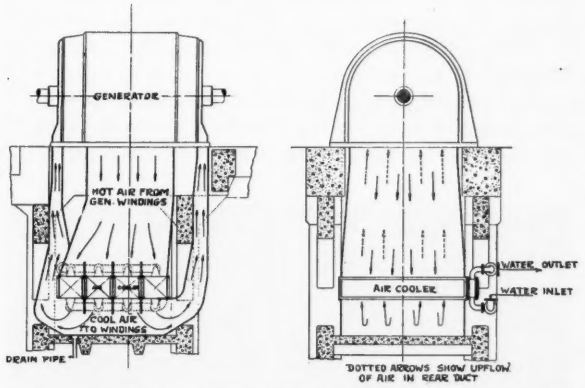


FIG. 1. TYPICAL INSTALLATION OF A GENERATOR AIR COOLER

Extreme compactness of the modern generator gives relatively small exterior heat radiating surface. This fact introduces the problem of eliminating the heat represented by the internal losses, with the resulting development of the fin-tube generator air cooler, operating in a closed air circuit.

There is a secondary use of an air cooler for this service, which is of considerable importance; namely, that of recovering the heat so generated, thus considerably reducing the losses in the system. This is possible only in installations that use condensate as a cooling medium, for it is by means of the condensate that the heat is recovered and returned to the system.

In present day practice, hot air leaving a generator passes through a closed duct to the cooler, where it comes in direct contact with finned tubes through which pass the cooling medium (either raw water or condensate). The air, when striking the cool surfaces, gives up a large part of its heat and usually leaves the cooler at a temperature of about 104 deg. F. (40 deg. C.). The air is returned through ducts to the generator, where it gathers more heat by cooling the generator windings and it then starts on another cycle. Thus we have a complete closed system using the same air over and over again.

In the usual case, the air is recirculated through the closed system by impellers installed in the rotor although, for some of the larger sizes of generators, external blowers have been installed, frequently in duplicate.

*Engineer, The Griscom-Russell Co.

The closed duct has two principal advantages, which are of utmost importance. The first is the elimination of dust and other foreign particles, thus assuring clean air. If care is being taken that the duct is free from dust and soot before the unit is started the first time, the operator need not worry about dirt getting into his generator, as the duct is air-tight. But if dust, soot, lint, and the like once gain admittance to the system, they would choke the insulation, retarding heat transfer and clog the air passages in the generator itself, preventing proper ventilation and promote the possibility of fire, as such particles are readily combustible and may easily be ignited by sparks. The closed system also prevents moisture from coming in contact with the generator windings, which, of course, would be injurious to them. The second advantage of the closed duct if fire should start, it would quickly burn out before serious damage resulted, as the oxygen present in the air in this system would soon be consumed and, as the ducts

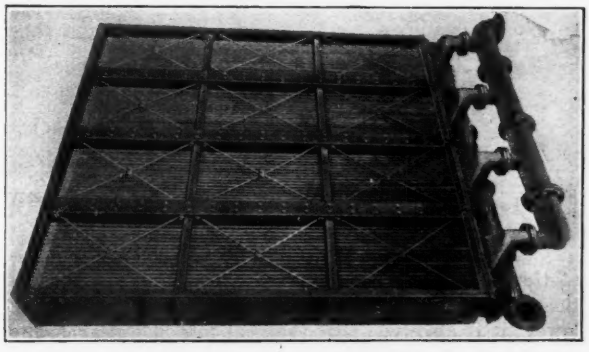


FIG. 2. SINGLE-BANK COOLER CONSISTING OF FOUR SECTIONS

are air-tight, no more could enter to promote complete combustion.

CLASSIFICATION OF GENERATOR AIR COOLERS

Generator air coolers may be conveniently divided into three classes, according to the character of the cooling medium: (a) coolers using raw water; (b) coolers using condensate; (c) those using both raw water and condensate.

Raw water coolers obtain their cooling water from sources of supply outside the power plant system, either from natural resources, such as rivers, lakes and the ocean or from wells or city mains. Water obtained from the first group is available in unlimited quantities and its temperature seldom exceeds 85 deg. F., while that obtained from city mains or wells is limited in quantity. Well water, however, is usually at such a low temperature that for small generators only a small amount is necessary.

Units using raw water are cheaper than those using condensate, because both a large quantity of water and a low inlet temperature reduce the surface to a signifi-

cant extent. This type of unit, however, does not return the absorbed heat to the system.

Coolers using condensate from the main condenser have a limited supply of cooling water and also have the disadvantage of an entering cooling water temperature considerably higher than that of the raw water units. For these reasons, the first cost of such a unit is greater, as more surface is required. The additional cost, however, is usually compensated for by the energy saved in the form of heat returned to the boiler in the condensate.

In using this type of installation, a problem presents itself when we consider the part load conditions, inasmuch as the quantity of condensate is greatly reduced

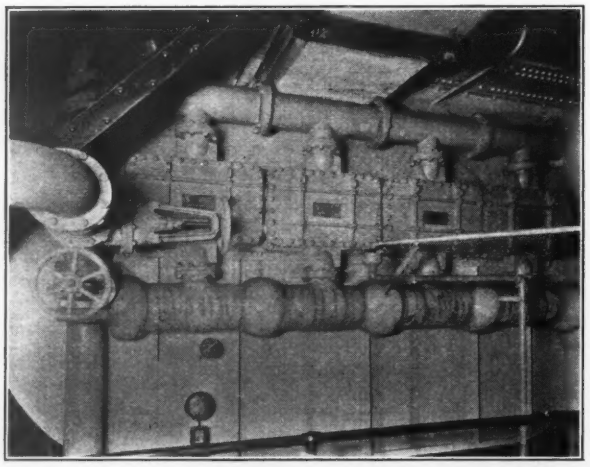


FIG. 3. INSTALLATION OF AIR COOLERS ON A 20,000-KW. GENERATOR

at the lower loads. It is true that the temperature of the condensate on entering the cooler may be somewhat lower; it is also true that the heat loss of the generator is reduced. But these two are not enough to compensate for the reduction in the quantity of condensate.

Some engineers have solved this problem by shutting off the condensate entirely at lower loads or in extremely hot weather and using raw water. This is not considered the best engineering practice, because when condensate again passes through the system it picks up the impurities deposited in the cooler and carries them to the boiler.

Lower load conditions can best be met by recirculating part of the condensate, which has been heated in the cooler, back through the main condenser where it is cooled and returned with the normal amount of condensate in sufficient quantity to do the necessary cooling.

Another good method would be to recirculate part of the condensate through a heat exchanger where it is cooled by raw water and returned to the cooler, supplementing the normal condensate flow as before. Of course, raw water is not always available to carry out this method. The reader should bear in mind that recirculating would only be necessary for certain low load conditions of short duration, therefore the heat wasted would be slight and the operating cost of the exchanger insignificant.

Operation of Double-Bank Coolers

A double-bank cooler is constructed in two entirely independent sections, one super-imposed upon the other, so that the air passes through them in series, one section using condensate and the other raw water to do the cooling. The higher temperature range is in the condensate bank of a properly designed cooler, since heat is more readily given up at high temperature differences; thus more energy is reclaimed by the condensate.

Such a unit may be so designed that the condensate bank does all or any part of the full load cooling, although the surface (consequently the cost of the unit) increases with the amount of cooling required of it. It will be shown later that the total surface of the entire unit and the cost of the unit may be increased by doing too little cooling in the condensate bank, although the surface of the condensate bank itself would be decreased. Of course, such a unit would be improperly designed.

The raw water bank continues the cooling where the condensate bank leaves off, therefore it may do no cooling at all or it may do considerable at the full load

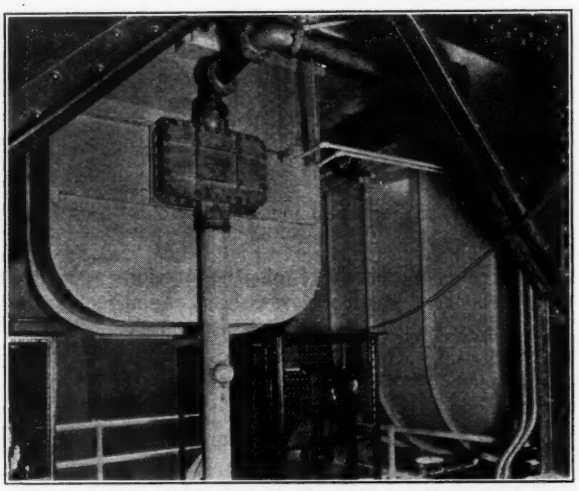


FIG. 4. AIR COOLERS INSTALLED WITH A 1000-KW. AUXILIARY GENERATOR, SHOWING DUCT ARRANGEMENT

condition, depending upon the design of the cooler. At part loads where the quantity of condensate falls off, the raw water bank gets in its important work and, as the load reduces, a properly designed cooler will do less and less of the total cooling in the condensate bank and more and more in the raw water bank, until at the no-load condition the raw water bank is doing the entire cooling. It is at this load, therefore, that the raw water bank is operating at its peak and it is for this low load condition that it is designed.

(To be continued.)

Reading Co., Philadelphia, Pa., operating the Philadelphia & Reading Railway, is arranging an expansion program for 1929 to cost about $35,000,000, of which a considerable portion will be used for electric and mechanical work, to include initial development of electrification in the Philadelphia district, a new pumping plant at Beaver Creek, new coal storage and distributing facilities and other structures.

Fourth Midwest Power Engineering Conference

VARIETY OF PAPERS* PRESENTED AT CHICAGO, FEB. 12-14. INTERESTING DISCUSSIONS OF SUBSTRUCTURE, CENTRIFUGAL PUMP DESIGN, 1200-LB. NORTHEAST ADDITION

AT THE FIRST session of the conference, on Tuesday afternoon, February 12, the general subject of the session was Power Plant Substructure Problems, L. R. Howson presiding. H. G. Roby of Byllesby Engineering & Management Corp. gave details of design and construction of the stream flow hydroelectric plant at Louisville, Ky. He pointed out that not only must costs be kept low but also that the substructure is both a water conduit and a foundation for building and machinery. He then described the principal features of the plant and dam, calling attention to the effect that the great variation in water level had on the design of substructure and the propeller type water wheels, which operate submerged most of the year. Construction methods used at this plant were effectively shown by motion pictures.

SUBSTRUCTURE PROBLEMS OF FOUR STEAM PLANTS

J. C. Sanderson of Sargent & Lundy, Inc., in a paper on Power Plant Substructure Problems, gave data from four recently built power plants to show the wide variation in the problems encountered and the method of solution in each case.

Referring to a plant at Mexico City, he stated that this city is near the center of a circular level valley supposed to have been a deep lake filled through the centuries with alluvial mud, volcanic ash and clay. The thickness of the present top crust floating on this sea of mud cannot be determined, as the water content increases with the depth to at least 50 per cent of the volume. When a considerable area of this is loaded, the settlement is in the form of a basin with the low point near the center of the load. It is not practicable to use piles, as the material gets softer with the depth.

Foundation for a new boiler room adjacent to the existing turbine room was designed as a light concrete barge with longitudinal and transverse steel trusses. Average load of 850 lb. per sq. ft. was adopted, with maximum of 1000 lb. at the edge of the footing and 520 lb. at the center owing to the basin form of settlement. The bottom slab is 10 in., the boiler room floor 6 in., the sides 8 in. Boiler loads and other concentrated loads were carried to the trusses by steel beams. There was no rigid connection between the two buildings. The old boiler room was torn down and a new turbine foundation built on the same principle as that of the boiler room. This plant has gone through a number of light earthquake shocks with no noticeable settlement.

FOUNDATIONS FOR POWERTON

At Powerton Station, near Pekin, Ill., (see Power Plant Engineering, Nov. 15, 1928) Mr. Sanderson stated that the top soil is a mixture of light clay and sand 4 to 6 ft. deep, with a deep bed of sand and gravel below. The lower point of the condenser pit is at extreme low water or 25 ft. below high water. Foundation is a concrete mat on the sand with a difference of 22.5 ft. between the bottom of the mat in the boiler room and condenser pit.

The work was done by excavating the entire site to the bottom of the boiler room mat. Steel sheet piling was driven around the entire area, about 120 by 145 ft. on the neat line of the concrete. Inside the sheeting about 1 in., were driven 12 to 18-in. I-beams on 2-ft. 2-in. centers. Bracing was framed in the sand. As excavation progressed, concrete was poured between I-beams and sheeting and after the bottom was poured the I-beams were encased in concrete by pouring a solid wall around them. The sheeting was then pulled and the space left was puddled with sand.

METHODS USED AT COLUMBIA

At Columbia Station, 20 mi. down the Ohio River from Cincinnati, Ohio, (see Power Plant Engineering, Feb. 1, 1926) variation of water level is 64 ft. and the soil is a light sandy clay on a thick bed of sand and gravel about 45 ft. below grade. As an experiment, it was attempted to install two piers by the Chicago well method but this was not successful because of a water bearing sand at 25 ft. below the surface. Several piers were installed with steel sheeting, braced as the excavation proceeded, then casting the pier in the dry.

Most of the piers were dredged down as was the condenser pit. The hollow piers were poured about 12 ft. at a time, the material dredged from the inside and the pier thus lowered to ground level when the process was repeated. When the pier reached the gravel, the concrete seal was poured through the water and a cap put on the top, leaving the hollow pier filled with water. The condenser pit 77 ft. in diameter, was sunk in the same way, close attention being required to keep it vertical and in exact position.

At Crawford Ave. station, Chicago, (see Power Plant Engineering, July 1, 1925) the soil is blue clay increasing in hardness with the depth, with hard pan 25 to 30 ft. below grade. Building walls and columns are carried on caissons founded on the hard pan, sunk by the Chicago well method. Turbine foundations are mat footings on the clay made strong enough to insure that the entire foundation for a machine would stay in one plane, so that a slight settlement would cause no trouble. Piping was made flexible to allow for a slight change in elevations. There has been no noticeable settlement, Mr. Sanderson said, in any of the six machines at Crawford.

At the noon luncheon meeting on Wednesday, Feb. 13, under the auspices of the Chicago Section A. I. E. E., with R. F. Schuchardt, president A. I. E. E. presiding, G. L. Clark, professor of chemistry at the University of Illinois, spoke on X-Ray Applications in Everyday Engineering Problems.

Professor Clark showed how x-rays by their many

*Abstracts of other papers delivered at the conference, together with important points brought out in discussion, will be given in a later issue.

applications in science and industry yield us knowledge of the ultimate construction of matter. He referred to investigations of metal castings with the x-rays, as at the Watertown Arsenal, examination of welds for soundness, of coal for slate and ash, of minerals for classification, of wood for airplanes, of piping, radio tubes and even of Swiss cheese for location and size of the highly-prized holes. Museums are using x-rays to examine old pictures and much of our knowledge of ancient anatomy is derived from radiographs of Egyptian mummies. Professor Clark discussed the nature and action of the x-rays and described an x-ray laboratory at the University of Illinois. He explained how the examination of the crystal structure of matter can be explored with x-rays and knowledge obtained far beyond the power of the microscope. He then noted the ways in which heat treating affects certain metals, as shown by the x-ray, and of its use in studying asbestos, lime, lubrication, and so on.

New Centrifugal Pump Theory of Professor Scherzer

Professor A. F. Scherzer of the University of Michigan discussed some recent developments in the theory of the centrifugal pump in a paper on Centrifugal Pump Economics at the Thursday afternoon session, presided over by Julius L. Hecht. He pointed out first some of the reasons for the differences between the theoretical curve of a pump and the curve actually obtained by a test. Prof. Scherzer, after considerable study and research, has concluded that this difference is caused by an error in the fundamental theory of the centrifugal pump, due to misapplication of Bernouilli's theorem.

When water flows in a pipe, he says, the theory correctly applied shows us that the total head is the pressure head plus the velocity head. When water is set in rotation in a cylindrical vessel, however, by a paddle or an impeller, a pressure is created by centrifugal force equal to $V_2^2 \div 2g$ which is part of the velocity itself. The total head may be regarded as either, but not both. The pressure exists because of the velocity in the circular path but not in addition to it.

It is clear, says Professor Scherzer, that the pump gives a head of only $V_2^2 \div 2g$ instead of $V_2^2 \div g$ as required by all present theories because the energy imparted is $V_2^2 \div 2g$ and the water can have no more energy than it is given by the impeller. He showed curves and test data from actual pumps to confirm this statement.

Use of Guide Vanes and Volutes in Centrifugal Pumps

He then discussed the use of guide vanes with figures to show that their benefits are founded on a misconception. As the water is confined in a circular path, he stated, its kinetic energy is converted into pressure without any assistance from the guide vanes. In fact, he said, they often serve to obstruct the natural flow of water. The same arguments may be extended to the volute or spiral casing. Apparently the only function of the casing is to restrain the water and compel it to move in a circular path; the development of pressure follows only because of the velocity and one may be said to measure the other. The very existence of pressure here indicates that the velocity has been converted into pressure. It is difficult to see, says Prof. Scherzer, how it can be done a second time, yet this is exactly what is supposed to be accomplished by the guide vanes and spiral casings. This, he says, shows how hopeless it is to expect any gain from use of guide vanes and spiral casings, since their advantage is based on conditions that can be proved never to have existed.

It would appear that the natural form of case is not the well-known spiral or volute but rather a plain concentric circular case of constant cross-sectional area.

Results of Pump Designed on New Theory

These conclusions were applied in design of a pump to test them. The resulting pump, said Professor Scherzer, showed higher heads for a given peripheral speed and lower relative losses for a given wheel diameter, thus effecting an increase of several points in efficiency as compared with that obtained in similar commercial designs.

The speaker then discussed in detail a new theory of the centrifugal pump that is extremely simple, without intricate mathematics, demonstrating it by examples and curves. This theory, briefly is based on the flow through three orifices in series: (1) the suction entrance to the impeller; (2) the discharge from the runner; (3) the discharge from the throat of the pump. Their combined effect determines the pump characteristic. The speaker stated that its continued application in actual practice has resulted in exceptionally good agreement between theory and practical results.

Northeast Station Installs 1200-Lb. Equipment

Description of the new high-pressure installation at Northeast Station of Kansas City Power & Light Co., is given in a paper prepared by Edwin Jowett of that company for the Friday morning session, A. A. Potter, chairman. Additional capacity was desired and with the existing equipment at steam pressure and temperature of 300 lb. and 700 deg., it was felt that practically no further improvements could be made in the economy of the station. The plant now contains three 23,000-kw. turbines and two 30,000-kw. units served by twelve 1350-hp. boilers. Accordingly, the addition was designed for 1200 lb. and 725 deg. at the turbine throttle, the unit to exhaust through reheaters to the 300 lb. station header. This equipment was ready for service in the fall of 1928.

Size of the turbine was chosen so that its output, together with that of the present turbines using its exhaust steam, would meet minimum load requirements and at the same time could be supplied with steam from two boilers of a size that would fit the vacant space available in the boiler house. While two boilers will normally be in service to carry full load on the turbine, the furnaces and fuel burning equipment are one boiler. Further details are given in the article on page 259.

Northeast Station Installs 1200-Lb. Pressure Plant†

By Edwin Jowett*

TO SECURE additional capacity with greater economy at its Northeast Station, the Kansas City Power & Light Co. has installed high-pressure equipment consisting of a 10,000-kw., 80-per cent power-factor turbine generator and two 17,000-sq. ft. boilers with reheaters, fired by pulverized coal, to give steam at 1200-lb. and 725 deg. at the throttle of the turbine, which exhausts through reheaters to the 300-lb. station header. The existing 300-lb. equipment consists of three 23,000-kw. generating units and two 30,000-kw. units served by twelve 1350-hp. boilers. Size of the high-pressure unit is such that its output plus that of the present turbines using its exhaust will meet minimum load demands; the two boilers are of a size to fit vacant space in the boiler room. One boiler can carry 7500 kw. load.

Investment costs were considered to be the difference between installation cost of two boilers of 300 lb. pressure of equal capacity and two high-pressure boilers with reheaters. The turbine gave additional capacity at practically the same cost per kilowatt as the 300-lb. unit and auxiliaries. Also, it was possible to locate the high-pressure turbine in the boiler room near the high-pressure boilers, thus saving on costs of piping, obviating necessity for a turbine room extension and lowering pressure losses in piping. Design of the new turbine generating unit is such that no trouble is anticipated from the dust of the boiler room.

Analysis of system load and proposed equipment indicated that the following results could be obtained in 1929:

Average B.t.u. per kw-hr. on 1200-300 lb. combination (assuming full load on hp. unit)	13,810
Average B.t.u. per kw-hr. on balance of 300-lb. units (assuming same as for 1928 performance)	16,800
Composite average B.t.u. per kw-hr. (net)	14,970

Comparison of relative costs of a 1200-lb. installation at Northeast Station and a 300-lb. installation was made on the basis that the high pressure job would furnish 10,000 kw. and steam for 45,000 kw., while boilers for the 300-lb. unit would furnish steam for 30,000 kw. and the turbine would be a 30,000-kw. unit.

Summary of the costs is as follows:

10,000-kw. turbine installation	
1400-lb. boiler (steam for a total of 45,000 kw.)	$1,342,138
1200-lb. turbine	307,246
	$1,649,384
300-lb. installation	
300-lb. boiler (steam for total of 45,000 kw.)	$ 918,000
300-lb. turbine	335,000
	$1,253,000

The high-pressure installation costs $396,385 or 31.6 per cent more than a 300-lb. installation of like capacity. If fixed charges at 13.25 per cent are figured on the difference between these two investments, the annual saving from operating the high-pressure equipment must at least equal 0.1325 × $396,385 or $52,500.

As previously shown, it is estimated that the heat consumption will be lowered from 16,800 B.t.u. per kw-hr. to 14,970 B.t.u. or 1830 B.t.u. by the operation of the high pressure equipment. For the annual output of 530,201,400 kw-hr. and with fuel at 67,000 B.t.u. for one cent, this saving in fuel will result in an annual reduction in cost of $144,700. This is nearly three times the fixed charges on the difference in cost of the two installations.

General Operation Conditions

Maximum pressure for which boilers are designed	1400 lb. gage
Normal operating drum pressure	1280 lb. gage
Pressure at turbine throttle	1200 lb. gage
Temperature of steam at turbine throttle	725 deg. F.
Back pressure at turbine exhaust at full load	315 lb. gage
Superheat in exhaust at full load	40 deg. F.
Pressure of steam out of reheater	290 lb. gage
Temperature of steam out of reheater	700-725 deg. F.

Description of 1200-Lb. Northeast Units

New equipment consists of two bent-tube boilers of 17,000 sq. ft. of heating surface each. Difficulty of getting forced draft chain grate stokers large enough to carry maximum load with the low grades of bituminous coal used in the station and experience with an experimental installation of two unit pulverizers firing a 1350-hp. boiler led to the adoption of pulverized coal for fuel. As the plant is away from business and residence districts, the fly ash problem did not influence the decision. It was possible to install a water-cooled furnace large enough to keep the combustion rate down to about 20,000 B.t.u. per cu. ft. of volume per hour at maximum rating and about 17,000 B.t.u. at normal rating, based on a furnace volume of 15,670 cu. ft.

Furnace below the burner line is of fin tube water walls on front and back and bare tubes on 7½-in. centers on the two sidewalls. Immediately back of the sidewall tubes are reheater elements of single loops of 1¾-in. tubes about 17 ft. 6 in. long. The front wall has secondary air ports and a hearth screen is provided at the bottom.

Nine forced draft burners fire down through a tile-backed water-cooled arch in each furnace. Upper sidewalls are of firebrick and insulating materials.

The two boilers are of the three-drum type with three gas passes and a 2650-sq. ft. convection superheater between first and second passes. Each boiler is served by three impact pulverizing mills of 15,000 lb. per hr. capacity each of 15-per-cent-moisture coal. Primary air is sent to mills at any temperature up to 400 deg., heated secondary air is admitted at the burner and tertiary heated air through the front wall.

Each boiler has a fin-tube economizer of 10,891-sq. ft. heating surface designed for 1490 lb. per sq. in. Each unit has a plate type air heater of 39,270 sq. ft. and

*Vice-President in charge of Power Plants, Kansas City Power & Light Co.

†Abstract of paper prepared for presentation at Fourth Midwest Power Engineering Conference, Chicago, Feb. 12-15, 1929.

forced and induced draft fans. Boiler feedwater is supplied by motor-driven 800 g.p.m. centrifugal pumps.

Turbine Generator Has Unusual Features

The turbine generator is of combined impulse reaction type rated at 10,000 kw., 80 per cent power factor. The turbine cylinder is machined from steel forgings and supported from the exhaust casing by steam-heated steel links from stationary brackets. A Kingsbury thrust bearing with handwheel adjustment for axial position of the rotor is provided. Turbine water rate will vary from 34 lb. per kw-hr. at full load to 45 lb. at half load.

Special care was taken in designing piping, valve controls and automatic regulators for the reheaters to maintain equal reheat outlet temperatures.

Arrangements have been made for feeding the high-pressure boilers entirely on condensate and a hot process lime and soda ash treating plant has been installed for treating makeup for the low pressure boilers. Special precautions have been taken to reduce condenser leakage to a minimum.

Centralized manual control of boilers is provided, arranged so it can be made automatic if found desirable later on.

Welding Used in High Pressure Boiler

Small Bore Tubes Joined Satisfactorily by Thermit Process. By K. A. Mayr

IN THE construction of the new high-pressure steam generator built by the Siemens-Schuckertwerke, Germany, the Thermit welding process is extensively used. This generator converts water into steam by the

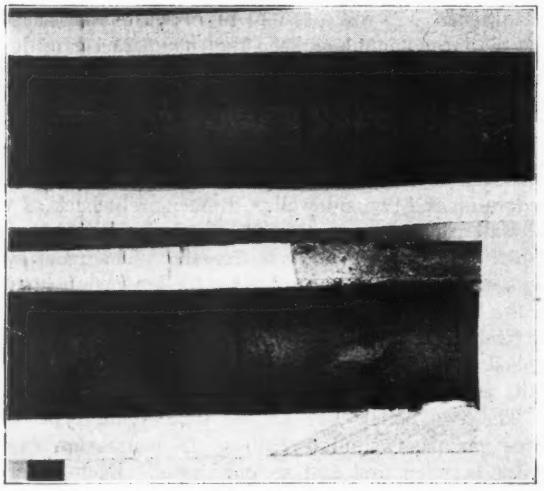


FIG. 1. THERMIT-WELDED JOINT, FULL SIZE

method suggested by Mark Benson, steam pressures up to 3200 lb. per square inch being available. The combustion chamber of the powdered coal fired generator is almost entirely surrounded by tubes through which water and steam are artificially kept in circulation at high velocities, with the utmost use of the radiant heat.

Tubes are of small bore and, owing to the particular furnace design and to the steam generating system which requires a flow of water and steam through long continuous tube lines, a great number of tube lengths had to be joined together. It was, therefore, unavoidable that many joints be directly exposed to the radiant heat in the combustion chamber. A heaping up of material on the joints, which would have increased the resistance to the heat transfer into the interior of the tube and thereby increased the temperature of the tube and joint, was unallowable. Furthermore, care had to be taken that the internal diameter of the tubes be not reduced at the joints, in order to avoid unnecessary resistance to the water and steam flow.

Method of Welding

Butt-welding of the tubes and the thermit welding process were chosen. The tube ends are ground flat

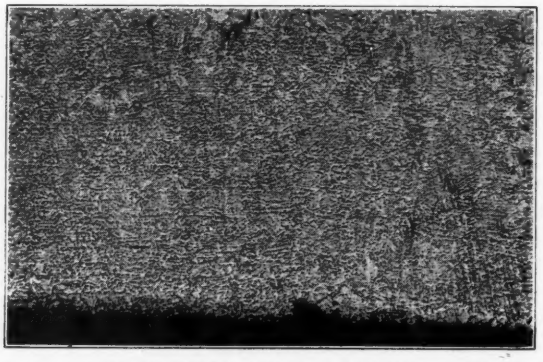


FIG. 2. WELD GROUND AND ENLARGED 15 TIMES TO SHOW STRUCTURE

and pressed together by means of clamps. A casting mold is fitted around the joint and filled with the right amount of molten aluminum oxide and iron, obtained by reaction of aluminum and iron oxide, according to the common practice of thermit welding. A short time, depending on the size of the tubes, after the casting mold has been filled the heat from the aluminum oxide and iron is sufficiently transferred and distributed over the tube ends to be jointed, and these ends are pressed together still more tightly by means of the clamps. Thus a melting and forging together of the tube ends is secured.

Thermit powder attains at its reaction a temperature of about 5400 deg. F. and acts as a heating agent, only. After cooling, which requires little time, again depending on the size of the tubes, the mold can be taken away and all the thermit removed from the tubes by a few light knocks with a small hammer. After the process, the outside appearance of the joint cannot be distinguished from the rest of the tube, Fig. 1.

Figure 2 shows a magnified and ground cut through the thermit-welded tube joint. The metal structure is absolutely homogeneous over the joint. Although the size of the crystals on some parts of the actual weld is slightly different from the size at parts farther away from the joint, the characteristic features of the structure are the same. The structure resembles that of a steel hardened at about 2450 deg. F. The tubes are low carbon steel, C 0.04, Mn 0.49, Si 0.02, Ph 0.032, S 0.032

per cents. Inside diameter 20 mm. (0.787 in.); outside diameter 33 mm. (1.299 in.). The pictures show a small groove on the joint which is caused by one of the tube ends not being absolutely sharp edged.

This groove is 0.28 mm. (0.011 in.). The thickness of the tube wall is 6.5 mm. (0.256 in.) thus the reduction of the tube wall thickness is 4.3 per cent of the total wall.

In order to investigate strength, a tube of nickel steel was welded as above and a rectangular test piece was cut out axially. The length of this piece, having the weld in the middle, was 75 mm. (2.952 in.), the width 7.17 mm. (0.307 in.) and the thickness 5.88 mm. (0.260 in.). Nickel steel of the following composition was used for the tube in this particular test, (the tubes usually used in the Benson boiler installations being of ordinary low-carbon mild steel): Carbon 0.085, manganese 0.37, phosphorus 0.011, silicon 0.1, sulphur 0.034, chromium 0.07, nickel 3.1 per cents. The yield point was at 3417.75 lb. or 52,187.4 lb. per square inch; the breaking point was at 4619.5 lb. or at 70,531.2 lb. per square inch; the elongation at rupture was 19.5 per cent; the reduction in area was 67 per cent, the fracture occurring outside the welded joint.

In the new boiler which has now been in operation for more than 2000 hr., about 130 thermit-welded joints are exposed to radiant heat and into about 50 heat is transmitted by convection. The average temperature of the tube walls is 700 to 800 deg. F. When the boiler was put under pressure and heat was applied for the first time, 5 per cent of these welds were found to be leaky. These were sealed by oxy-acetylene welding and no trouble or irregularity whatever was experienced thereafter.

Coal Classification Receives Study

FACTORS TO BE CONSIDERED IN DEVELOPING A UNIFORM AND ADEQUATE SYSTEM OF COAL CLASSIFICATION

RECENT ACTION of the American Engineering Standards Committee in taking up the classification of American coals is bringing into prominence the fundamental importance of knowledge of the constitution and composition of coal. This work was outlined by A. C. Fieldner, Chief Chemist of the U. S. Bureau of Mines and chairman of the committee, in a paper presented before the Second Fuels Meeting of the A. S. M. E.

How to reconcile the different points of view of the scientific, engineering and commercial groups in working toward the common goal of a uniform and adequate system of classification was the outstanding problem that faced the sectional committee. The scientist naturally classifies on the basis of his particular type of knowledge; for example, the chemist on the basis of chemical composition, the paleobotanist on the types of plant remains in the coal, and the geologist on the degree of metamorphism of the plant remains.

Various ranks assigned to American coals in progressive order, beginning with the youngest stage in coal formation, are peat, lignite, sub-bituminous, bituminous, semi-bituminous, semi-anthracite, anthracite, and superanthracite. The bituminous rank is again subdivided into low-, medium- and high-rank bituminous coal; the semi-bituminous, into low- and high-rank semi-bituminous coal.

Simple chemical tests and physical characteristics of the coal are criteria for classification; the proximate analysis is sufficient to differentiate the ranks from bituminous to anthracite, but physical characteristics are essential, in addition to the proximate analysis, for identifying sub-bituminous coals and lignite.

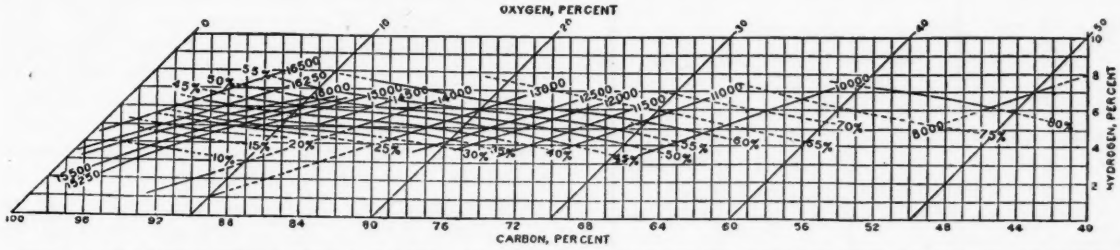


FIG. 1. RELATION OF CALORIFIC VALUE AND VOLATILE MATTER OF COAL TO THE ULTIMATE ANALYSIS

ULTIMATE ANALYSIS NOT GENERALLY AVAILABLE

Ralston's trilinear diagram based on the hydrogen, carbon and oxygen content of the coal gives a definite relation between the ultimate analysis of coal and its calorific value. Although this fact was previously known, since calorific values may be calculated to within 1 or 2 per cent by Dulong's formula, the diagram shows the relation more definitely and enables one to determine the ultimate analysis directly from the graph if the volatile matter and the calorific value are known.

Relation of the calorific value and volatile matter of coals to the ultimate analysis, shows intersecting "isocal" and "isovol" lines obtained by joining the points representing coals of equal calorific value and likewise the points representing coals of equal volatile matter.

Such a chart is shown in Fig. 1, where corrections for sulphur have been applied to the calorific values before plotting them. This form of graphical representation permits of applying either ultimate analyses

or volatile matter plus calorific values to the identification of a given class of coal, or if the classification criteria are given in terms of percentage of carbon, hydrogen and oxygen, the equivalent criteria for this class can be determined in terms of volatile matter and calorific value. This comparison is advantageous since proximate analyses and calorific values are more generally available than are ultimate analyses.

Professor Parr has utilized this relation in his system of classification. Figure 2 shows Parr's system in

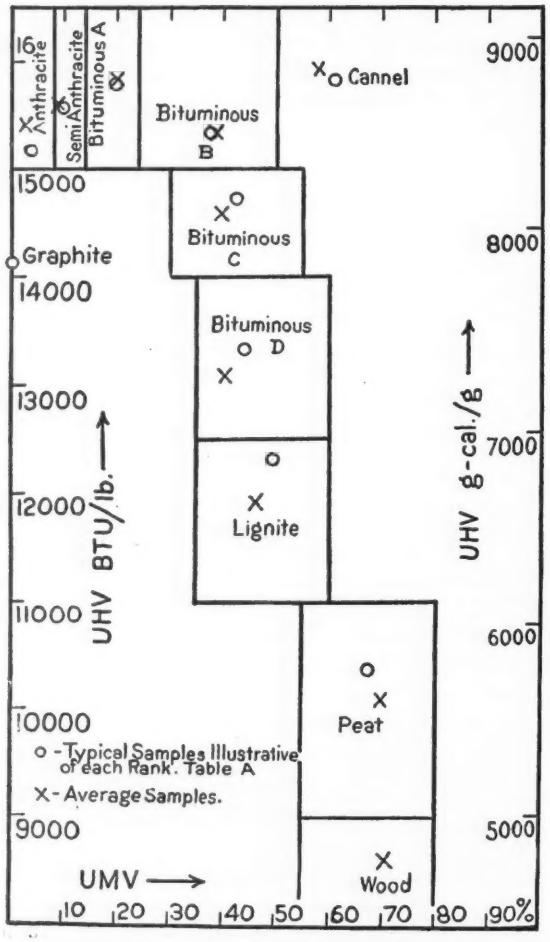


FIG. 2. DIAGRAM SHOWING PARR'S SYSTEM FOR THE CLASSIFICATION OF COAL WITH CALORIFIC VALUES IN B.T.U. PLOTTED AS ORDINATES AND THE PERCENTAGE OF VOLATILE MATTER AS ABSCISSAS

which the calorific values in B.t.u. are plotted as ordinates and the percentages of volatile matter as abscissas. Both values are given in terms of "unit" coal, that is, calculated free from moisture and ash and corrected for sulphur and water of hydration of shaly matter. This system has the merit of simplicity as compared to the ultimate analysis system but, of course, does not give as much differentiation of various kinds of coal. Nevertheless, its close relation to the ultimate analysis system and its ease of application justify its incorporation in any scientific method of classification.

In summarizing the program of the sectional committee on the classification of coal, the following important considerations are being kept in mind:

1. Coal should be classified primarily on the basis of its intrinsic chemical and physical properties. These properties involve the origin, composition and constitution of the coal.

2. Use classification should be secondary to scientific classification and should be correlated with the scientific classification as far as possible.

3. Scientific classification depends on two primary factors, first, the composition and type of the original coal forming vegetation, and second, the degree of metamorphism or coalification of the vegetable residue.

4. The first factor is described broadly in the type of the coal, as xyloid, canneloid, or boghead; the second factor in the progressive rank of the coal as expressed in the series from lignite to anthracite.

5. The criteria to be considered for classifying under these two general factors are proximate and ultimate analyses, calorific values, microscopic examination, extraction with solvents, reaction with reagents, and destructive distillation.

Instantly, How Quick Is It?

SPLIT SECOND timing and measurement of the flight of a bullet seem quick enough action for all purposes. They do not serve, however, when scientists and engineers start keeping tabs on lightning.

In racing, even for automobiles and aeroplanes, the speeds are but a small fraction of a mile per second. The high-power rifle or cannon starts its projectile at the puny velocity of a few miles per second. These are slow-motion movies compared to the lightning at 186,200 mi. per sec. If lightning is to be checked up, the record must be instantaneous, with no ifs about it.

Hopeless as the problem might seem, it is important to solve it in order to provide adequate protection to transmission lines and connected apparatus. So a new servant is impressed, the cathode ray oscillograph and a manufactured bolt of lightning is sent into a 220,000-v. transmission line to see what happens.

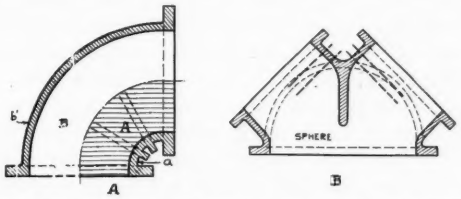
Well, the voltage rose to 2,500,000 in *ten one-millionths of a second.* It was measured on the oscillograph record. Then by oscillations it swung back to 220,000 v., the whole operation, from lightning stroke to the return to normal, taking 40 one-millionths of a second.

That is how near Dr. F. W. Peek, Jr., of the General Electric laboratories, who is carrying on the work of the late Dr. Charles P. Steinmetz, has come to instantly. And that is how fast protective devices must operate to prevent damage by lightning. The problem is not yet solved but such data help toward a solution.

TO AROUSE INTEREST in attending the World Engineering Congress at Tokio, Japan, in October, 1929, ninety local committees have been organized, as announced by Dr. Elmer A. Sperry, chairman of the American committee of arrangements. President-Elect Hoover is honorary chairman of the committee. It is also announced that the President Jackson of the Dollar Line has been reserved exclusively for the American delegation, to sail from San Francisco Oct. 11 and that 150 applications for accommodations are already in hand. Those desiring to go are urged to make early reservations with the American Express Co., which is handling the details of the trip.

Breakage of Fittings Under Pressure

AROUND POWER PLANTS we find two principal kinds of cast fittings involved in most of the breakages or failures under pressure. The most fruitful source is the common short radius elbow, which causes, on account of the unequal lengths of the bounding shells of metal, as seen in a cross section, containing the principal radius, the metal on the short side of the curve to be much more highly stressed than on the long side of said curve. A glance at Fig. 1A will show this at once.



PREFERRED DESIGN OF SHORT RADIUS ELBOWS AND SIAMESE FITTINGS

Simple consideration of the pressure areas shows that the area A, as cross-sectioned horizontally, depends on the metal section a′ for support while that of B depends on the metal section b′ to hold it together. To keep the unit stresses on both sections somewhere near the same, it will usually be found necessary to thicken the metal on the short side of the curve, depending on the shortness of the radius of the bend, and sometimes it will be necessary to insert ribs as shown. These ribs should be arranged so as not to interfere with the nuts of the bolts that straddle the centerline, and in cases of close clearances, go to a special fitting rather than try tapping the bolts into the elbow flange as such tapped holes in castings are usually unsatisfactory. The ribs should extend half way around the fitting and be of the conventional "half moon" shape.

Another type of fitting often incorrectly designed is the Y-branch or so-called Siamese fitting, Fig. 1A. The strongest shape for any vessel under internal pressure is the hollow sphere and in the case of the Siamese or Y branch, we can use the half sphere to form the body of the fitting and have the two branches join it as shown. In cases of fittings where the internal pressure is of any consequence, suitable thought should be given to the design. The splitter, or dividing wedge, can be run quite far back and can be made rather heavy to keep the stresses down to a suitable figure. The radius at the juncture of the two branches should be as large as can be used while, at the same time, taking care that the metal at the heavy part of the intersection is not more than about twice that of the outside walls to prevent possible spongy metal there. In cases of fittings where the internal pressure is very high, the strength can be much increased by adding cross ribs as shown in heavy dotted lines.

Much the same line of reasoning applies to the common lateral, having a straight run and an angular branch usually at 45 deg. Those selecting fittings for power plant work should remember that the shock to which piping is often subjected is of quite as much importance in any consideration of strength as the direct pressure in the fitting. The matter of temperature has not been mentioned above, for it is assumed that cast iron fittings will not be used where there is both pressure and great heat.

One does find, from time to time, power plants where the first cost dictated the use of cast iron fittings for steam, and where fittings have blown up and damage with loss of time has followed which has more than balanced the cost of steel castings or forged fittings.

York, Pa. JOHN S. CARPENTER.

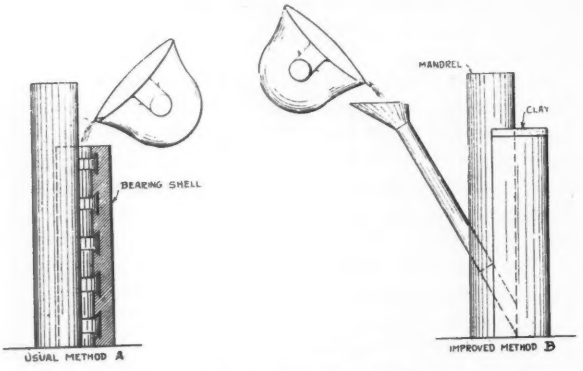
Bottom Poured Babbit Forms Superior Bearing

IT IS COMMON practice in babbiting large bearings to pour the babbit into the space between the bearing shell and the mandrel as indicated in the sketch to the left. This practice is satisfactory for bearings having a diameter less than about 12 in. In babbiting larger bearings in this way, however, it has been found that a number of gas pockets and blowholes develop, on machining the lining. These gas pockets and blowholes are formed as a result of the imprisonment of gas bubbles and air in the metal during solidification. The more the metal is agitated in the mold the greater is the number of holes produced. In babbiting small bearings, the babbit is poured from a relatively low height, consequently there is little agitation of the molten metal. When babbiting larger bearings, however, the babbit is, of course, poured from a greater height and the splashing and agitation of the metal is naturally much greater, with the result that a considerable number of blowholes and air pockets are formed.

When the babbit lining has been turned down to the required thickness, the blowholes are filled in with the babbit metal by the use of a hot soldering iron and

the babbit machined again to remove excess metal. It is obvious that considerable time and labor must be spent, if there is a large number of blowholes; the writer knows of cases where up to three days have been required to make a perfect babbit lining to large bearings.

It has recently been found that by bottom pouring the babbit, as indicated at B in the illustration, only a few blowholes and air pockets—often none at all—are formed even when babbiting very large bearings. When using this method of pouring, the babbit rises from the bottom upwards, forcing the air and the gases ahead of it, so that a solid lining is formed. The agitation and splashing of the molten metal are naturally, much less than when the metal is poured in the old way and the chance of air and gases getting imprisoned in the metal is consequently much less. Since the babbit shrinks on passing from the molten to the solid state, it is good practice to put a layer of clay or some other material, ½ to 1 in. thick, on top of the shell as indicated in the sketch to allow for the shrinkage. As in



POURING BABBIT FROM BELOW REDUCES AGITATION AND AVOIDS FORMATION OF BLOWHOLES AND AIR POCKETS

the case of any vertically poured bearing, provision must be made to permit building up the casting in the mold by blocking off the face of the bearing. Since the babbit metal solidifies in the tube, the separation of the mandrel from the bearing is not as easy as when using the old method of pouring. This disadvantage is, however, insignificant in comparison with the saving in time and labor due to the far better lining obtained. The method described is being used by one of the largest users of babbit in this country.

What is really surprising about this new method of pouring babbit is that it has not been introduced long ago. For many years it has been known that bottom-poured metal ingots are superior to those poured from top. High grade steel ingots, for instance, are bottom poured, since it has been found that the number of blowholes and other defects is reduced and the percentage of rejections of the finished product is less than when the ingot is poured from top.

Chicago, Ill. JAMES SILBERSTEIN.

NEW ORDERS for 1416 steel boilers were placed in November, 1928, as reported to the Department of Commerce by 72 manufacturers comprising most of the leading firms in the industry, as compared with 1518 boilers in October, 1928 and 1235 in November, 1927.

Save Coal by Using Boiler Room Instruments

WHEN A MANUFACTURING plant decides to install boiler room instruments, it may be presumed that it does so through a desire to save coal—which is to say money—and to save it in sufficient quantities to pay for the instruments and leave a profit. If the instruments are installed on old equipment, this is pretty sure to be the case. When they are installed with a new unit, the same thought is in somebody's head but not necessarily in the head of the management. The instruments might have been included by the designer with the rest of the equipment and simply accepted by the management as a necessary part of the works. This may account for the number of boiler rooms in which the instruments are present but not voting.

If the boiler room is in charge of a high-grade chief engineer, he will see to it that his instruments are kept running, that the firemen are guided by the instruments and that they will so control their fuel bed and draft regulation as to produce good combustion conditions. He will see to it that the boilers are kept clean and the baffling tight, thus keeping the flue gas temperature down to a reasonable limit.

In a good many comparatively small boiler rooms, there is no such man in charge. Still someone, at some time, has had the boilers equipped with instruments. It is frequently the case that these instruments are not in operation. I know of one industrial boiler plant which burns approximately 700 t. of coal a week. The only instruments, aside from the steam gages, are some oil draft gages which rarely read correctly and a CO_2 recorder. The latter can be connected to any one of a battery of four boilers. It is not used because, for months, it has been out of adjustment. A combustion test on this plant showed it to be approximately 65 per cent efficient.

In a nearby city, this manufacturer has a competitor burning a somewhat smaller tonnage of coal. The boilers and stokers in this plant are of a type similar to those in the first-named plant. Exactly the same coal is burned in both plants. The second plant gets 76 per cent overall efficiency, which means it uses 14.5 per cent less coal than its competitor to do the same work. If the first plant raised its efficiency to 76 per cent, which it can do, it would save approximately 100 t. of coal or $350 a week.

The only real difference between these two plants is that one is practically without instruments and the other has instruments and uses them.

A boiler instrument, as distinguished from a combustion control device, is simply a recording meter. It shows what is going on inside the boiler and furnace but it has no power to correct conditions when things go wrong. To be of any value, the information which it records must be used. When the CO_2 percentage drops, the fireman should adjust his dampers and fans and condition his fuel to bring it back to the desired amount. When the flue gas temperature goes up and it can not be accounted for by increased load on the boiler, an investigation of the reason for it should be made. It seldom happens that the temperature will make any sudden jump except for increased load when

it will drop back to normal as soon as the load drops again. What can usually be expected is a gradually rising daily average from one boiler cleaning to the next.

Now, the way to make boiler instruments valuable is to use them. This means, first, that they must be kept functioning. They are so rugged today that they require little care but they must have this little. The charts must be changed daily. The connecting lines must be kept clean. Finally, somebody must see the charts and see to it that the record they show is the kind of record that means efficiency. This somebody should be inside where the bills are paid. He does not need to know what to do about it when the charts report the wrong kind of story. He needs only to know how to read and have authority to get action when action is needed.

If the instruments are in the boiler room, somebody outside the boiler room once authorized the expenditure for them. If that somebody will take a few minutes once a week to look over the charts, he will have made a wise investment. If he doesn't, or does not at least delegate somebody else to do it and report to him occasionally, he has simply made a gamble. He is gambling on the men in the boiler room to break their backs making pretty charts when nobody seems to give a whoop what they look like.

A little executive attention is all that boiler room instruments need in order to pay dividends.

Pittsburgh, Pa. HOWARD W. MORGAN.

Proper Mixture, Essential for Bearing Metals

IT IS SELDOM a profitable procedure for a power plant engineer to make an article for use in the plant when a properly tested and proved article of the same kind can be bought from a reliable manufacturer.

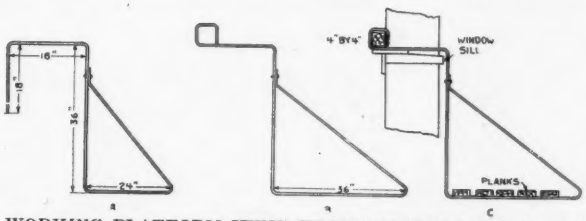
Thirty-five years ago, I was employed in the works of the Canadian General Electric Co. at Petersboro, Ont. There was a man in full charge of all the shafting throughout the works while my work was to attend to all the pipe fitting. He had the idea that he could mix a better bearing metal than any that could be bought, which, judging from some recent letters printed in power plant journals, appears to be the opinion still held by some engineers. He swore by his formula for babbit metal, which was of a tin-base type. The engineer also had his own idea about a bearing metal which consisted of lead, tin and antimony. Things came to such a pass that the two men were continually disputing among themselves about the merits of their mixtures. Ultimately the matter was referred to the superintendent of power, who gave his opinion that a bearing metal with a lead base would be superior to one having a tin base.

Since the early times, herein stated, I have come across engineers in different parts of the world and right up to date, who persist in mixing their own babbit metal, although every power plant journal carries advertisements from manufacturers who have made such metals and tested them repeatedly under the severest conditions. A man mixing metals for his own use may not understand that the metals used in making bearing metal, such as tin, lead, antimony, melt and mix properly, under widely differing temperatures. When a metal, even harder than antimony, is used in conjunction with tin and lead, the harder metals should be melted first. I have seen a man making a metal mixture containing tin and copper, among other metals, and he melted the tin first instead of the copper. I have mixed and used bearing metal many times and have secured better results from a lead base metal than from a tin base one. The metals I used were either antimony and tin, or antimony and lead. A metal containing 25 parts of antimony and 75 parts of lead gave the best results in my case.

Toronto, Canada. JAMES E. NOBLE.

Construction Bracket Hung from Window

RECENTLY WE RAN SEVERAL pipe lines along the side of our buildings and as the length of the run was too great to justify putting up a staging in order to erect hangers, hang the pipe and cover it, we devised the hanger, shown at A, to be hung out of the windows.



WORKING PLATFORM HUNG FROM WINDOW IS HELD IN PLACE BY 4 BY 4-IN. BARS WHICH PROJECT ACROSS THE WINDOW

They were made wide in the throat to allow for projections on the wall such as piping and benches. Planks were extended from one hanger to another, thus providing a continuous working platform.

Improvement was afterward made in the hanger as shown at B and C by constructing a hollow square at the end of the inner projecting portion. Through the hollow square a 4 by 4-in. wooden bar was inserted, extending out on each side across the window. This hanger was simple to make and easy to handle.

Waltham, Mass. THOMAS A. WALSH.

Improper Pulley Face Causes Belt Trouble

INSTALLATION OF A NEW heavy duty pump was made with all possible care as to alinement of the pump shaft but when the belt was put in place and the pump started, all the skill and experience of the engineer was useless in his effort to make the belt track properly from one pulley to another. The engineer even went so far as to disconnect the pump pipe connections and to twist the pump around slightly, first one way then the other, but without success.

Immediate service of the pump being absolutely necessary, the engineer replaced the pipes and placed the pump in its original lined up position. The belt again running off at one side, several strips of thick cloth, felt or sacking were wrapped around the pulley

and fastened to it by means of a very tenacious material made of common rosin and machine oil. About 1 lb. of rosin and a little less than one gill of machine oil are put in a clean can and placed on the steam chest to warm up. This stirred occasionally until the rosin is dissolved and thoroughly mixed. The mixture is tested by placing a smear of it between two bits of cloth which, when cold, is pulled apart and more oil or rosin added according as the mixture is found to be too thick or too thin.

Crowned thus with rags, the pulley ran for several months with no signs of the lagging coming off. Finally, when closing down of the factory for a few days presented an opportunity, the cloth was stripped off the pulley face and the pulley calipered. The pulley was found to be larger in diameter at one side than at the other. A straightedge was then applied to the face and this was found to be flat and not crowned as it was thought to have been. In fact, the pulley was actually cone shaped, being gradually smaller diameter as measured from one side to the other and the belt had crept up on the higher side as it would be expected to do.

After being returned in a lathe and properly crowned, the pulley was reinstalled and gave no further trouble.

Indianapolis, Ind. JAMES F. HOBART.

Packing Needs Graphite if Water Is Acidified

REFERRING to Howard Chester's article on reducing wear on packing, published on page 73 of the January 1 issue, it is likely that the water he is pumping does not contain acid. In our plant, the water we are pumping with our centrifugal pump contains considerable acid, in which case it is necessary to lubricate the packing with a mixture of graphite and grease.

We use the best flax packing made in America for our centrifugal pump. Before I used graphite and grease, I had to pack the pump every week but now the pump will run a year without needing repacking.

Seymour, Conn. CHARLES MEHR.

Enriched Air for Combustion of Low Grade Fuel

FOR THE EFFICIENT combustion of low grade fuel the use of enriched air or air having more than its usual proportion of oxygen has much to recommend it. Enriched air does not add to the number of heat units available, but it tends to give more efficient combustion by reducing the amount of nitrogen carried into the furnace and consequently the amount of heat carried away in the flue gases.

The oxygen content of air can be increased by a process of centrifuging. Air is passed into the center of a rotating separating drum or turbine fitted with vanes which revolves at high speed, the supply of air to be used is drawn from an outlet on the circumference of the drum, the remaining air being discharged through the hollow shaft of the machine. The first supply is rich in oxygen while the second is weak.

Relative densities of oxygen and nitrogen differ slightly in about the ratio 8 to 7, so by rotating the turbine at a high speed a partial separation of the gases can be secured, the air which is thrown to the periphery being rich in oxygen while that discharged in the centre of the machine has been weakened. The maximum enrichment which would appear to be obtainable by this means is about 30 per cent, the oxygen content of the air being increased to 27 per cent.

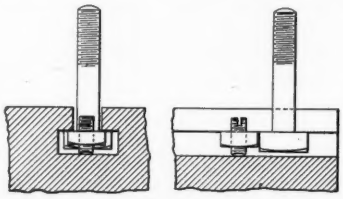
In many cases, it is much less, say 15 per cent, which gives an oxygen content of about 24 per cent, this having been found sufficient for all practical purposes. A peripheral speed of 400 ft. per sec. with turbine blades 14.5 in. in diameter will give an enrichment of 30 per cent but as the percentage enrichment is proportional to the square of the velocity and the power required to drive the machine increases as the square of the speed of rotation, high speeds may not be economical as the power consumption of the machine may outweigh any saving in the boiler plant.

Where low grade fuel has to be burned, the use of enriched air has much to recommend it and machines for this purpose have been used to some extent.

Brentford, Eng. W. E. WARNER.

Simple Device Prevents Bolt from Slipping

SKETCH HEREWITH shows how easy it is to prevent a bolt from sliding in a slot. An ordinary nut and set screw placed below the bolt head will keep the bolt



SET SCREW AND NUT IN SLOT HOLD BOLT IN POSITION

from sliding downward if the slot is vertical. If the slot is horizontal and it is desired to lock the bolt so that it will not slide in either direction, one of the locking devices is placed at each side. By turning the screw in the nut, with a screwdriver, the nut is pressed up against the lower surface of the slot and is held rigidly.

Newark, N. J. W. F. SCHAPHORST.

Compressed Oxygen Forms Explosive With Oil

IN A WESTERN MILL where a Diesel engine had been installed, trouble was experienced in starting it up. The starting air pressure ran so low that it became insufficient to turn the engine over. Someone suggested connecting up the oxygen bottle of the welding outfit to the engine and this was promptly done. At the next trial of starting, the engine turned over, but one atomizer exploded, literally flying to pieces and peppering the building with holes. As it had been placed at a high level, nobody was hurt. But the next move was to go to another Diesel plant, borrow an air bottle and resolve never again to use oxygen.

I trust readers of this short article will remember that oil, fuel oil and grease are to be kept away from oxygen under pressure, because of the explosion that may occur.

Death Valley, Calif CHAS. LABBE.

Questions and Answers

Fuel Oil Correction for Temperature

IF YOU HAD 1560 gal. of fuel oil at 105 deg. F. and the Baumé reading was 16 deg. at 60 deg. F., how many gallons would you have, corrected to 60 deg. F.?

If a gallon of fuel oil at 132 deg. F. weighs 8.07 lb., would the Baumé reading be almost 15 deg.? If so, it seems to me that fuel oil would be heavier than water.

J. C. D.

A. An approximate rule for correcting hydrometer readings of crude and fuel oil is that the Baumé reading will increase 1 deg. for each 10 deg. increase of temperature of the oil. Applying that rule would give a corrected Baumé reading of 11.5 deg. at 60 deg. F. for the oil that tested 16 deg. Be. at 105 deg. F. Further, the specific gravity corresponding to 16 deg. Be. is 0.9589 and that corresponding to 11.5 deg. is 0.9894. Therefore, the volume of 1560 gal. at the higher temperature would be less at 60 deg. in proportion to the specific gravities just mentioned, which gives an approximate volume of 1513 gal. by volume at 60 deg. F.

2. If a gal. of fuel oil weighs 8.07 lb. at 132 deg. F., the Beaumé reading at that temperature would be approximately 14½ deg. when using a hydrometer graduated for liquids lighter than water. An application of the rule mentioned in the answer to the first question, however, would show that at 60 deg. F. the reading by the same hydrometer would be less than 10, that is the liquid, when at 60 deg. F., would be heavier than water but not heavier than water when at 132 deg.

If the reading of the sample in question were of commercial importance, it would be much better to take a small sample and cool it to exactly 60 deg. before testing. Then the volume could be corrected in inverse proportion to the specific gravities and the result would be as accurate as the measurements taken.

Pressure Drop in Steam Line

WE HAVE AN 800-hp. boiler on which we carry steam at about 80 lb. pressure. This supplies steam to a milk drier which stands in another room. The steam pressure at the boiler end of the 3-in. steam main connected to the drier is 50 lb. gage. The main is about 25 ft. long and has three elbows fitted in it.

What would be the pressure difference between the two ends of this main? L. A. S.

A. Drop in pressure for such a low pressure and short distance should be small. A 3-in. elbow offers the same resistance to flow that 5.72 ft. of pipe offers, therefore the length of pipe to be assumed would be $25 + (3 \times 5.72) = 42$ ft. The absolute steam pressure will be $50 + 15 = 65$ lb. Since you have not stated the velocity of the steam through the main nor the weight of steam passing in pounds per minute, we are assuming flow of 50 lb. per min. Drop in pressure may then be calculated by use of the following equation:

$$p = 0.000131\ [1 + (3.6 \div d)]\ W^2L \div D\ d^5$$

where p = pressure drop in pounds per sq. in.
D = wt. of steam per cu. ft. (From steam tables at 65 lb. abs. = 0.1503)
d = internal diameter of pipe = 3 in.
W = weight of steam passing = 50 lb. per min.
L = length of pipe in feet = 42

then $p = 0.000131\ [1 + (3.6 \div 3)]\ (50^2 \times 42) \div (0.1503 \times 3^5)$
$= 0.000131 \times 2.2 \times 105{,}000 \div 36.52$
$= 0.8$ lb. pressure drop.

Force Required to Stop Descending Elevator

IF AN ELECTRIC elevator of the traction sheave type, weighing 2500 lb., overcounterweighted 40 per cent and traveling 450 ft. per min., is suddenly brought to a stop, what is the pressure or stress produced?

W. E. C.

A. If the elevator is overcounterweighted, the counterweight would weigh 140 per cent of the weight of the elevator car and its attachments. The length of time required to stop the descent of the car was not stated. We are, therefore, assuming this time to be one second.

The force required to stop the car is obtained by the equation $F = (W \div g) \times a$

Where F = the force or pressure in lb.
$g = 32.2$
a = the deceleration or uniform retardation during stoppage in ft. per sec. per sec.

and $a = (V_1 - V_2) \div t$

where V_1 = initial velocity in ft. per sec. $= 450 \div 60 = 7.5$ ft. per sec.
V_2 = final velocity $= 0$
t = time in seconds $= 1$

therefore $a = (7.5 - 0) \div 1 = 7.5$ ft. per sec. per sec.
Over counter balance weight $= 2500 \times 1.40 = 3500$ lb.
Effective weight to be stopped $= 2500 + 3500 = 6000$ lb.
Substituting in the above equation, we have:
$F = (6000 \div 32.2) \times 7.5 = 1400$ lb.

The above obviously neglects friction.

WISCONSIN POWER & LIGHT CO., Madison, Wis., has acquired a tract of about 200 acres of land on the lake front near Sheboygan, Wis., and is reported to be planning the construction of a steam power plant to cost about $500,000.

Editorial Comment

Take Off the Operator's Blinders and Give Him a Telescope

"There is a crying need," says the A. S. M. E. Power Committee, "in connection with our newer stations, for better operation. The concentration of responsibility for operation in the hands of fewer men, the vastly increased value of the avoidable losses under the control of each operating man and the unavoidable complexity of the equipment which we must use to obtain a fuel economy of 15,000 B.t.u. per kw-hr., or lower, all justify and make imperative a high degree of intelligence in the men who operate our stations.

"Intelligence is not enough, however. These men should be given every opportunity to acquaint themselves with the details of construction and the operating principles which underlie each piece of equipment. One of the most important opportunities of which we are now in large measure failing to avail ourselves is that of making provisions so that to a greater extent the results of the work that is being done by the N. E. L. A. Prime Movers' Committee and the A. S. M. E. Power Division shall filter down to these men who are actually operating the stations. Their help is needed, if power costs are to be further reduced."

Example I. Visiting a large power plant several weeks ago, one of the editors found new boilers fired by pulverized coal, a new turbine generator and the most up-to-date accessories, all combined in one of the most simple, pleasing and easily-operated installations he has seen. It was soon discovered that the home office of the utility had instructed the operating engineer to work out some method for the elimination of cinder and fly ash from his flue gas, as the plant was located in the center of a large city.

The chief laid down a barrage of questions. Where could he get information about what had been done and who makes the equipment for this work? In some surprise, the editor said, "Haven't you seen the N. E. L. A. Prime Movers' Committee reports for the past two years and the latest A. S. M. E. paper on the subject? You will find there references to many plants using cinder eliminating devices and many descriptions of the manufacturers' equipment available." "Where can I get these reports?" asked the chief. "I never see any of the ones you mention." Yet the editor remembered that in the head office, on the desk of the general manager whom he had visited before going to the plant, was a pile of the latest N. E. L. A. reports.

Example II. A few days after the above experience, another editor visited a large, new hydroelectric plant. After inspecting its interesting features, he returned to the office where the superintendent asked for help in answering a letter he had received. The letter was from an engineering society asking the superintendent to serve on a committee to investigate the subject of hydraulic turbine gate leakage and water measurements and asking further that he suggest methods of investigation to be followed and questions that might be asked various companies to determine their practice.

"But a large amount of work has already been done on that subject," said the editor. "It has been completely discussed in a recent report of the N. E. L. A. Hydraulic Power Committee. Don't you ever see those reports?" "Never heard of them," replied the chief. "I know that the company is a member of the N. E. L. A. but I didn't know that any reports were issued giving that sort of information. I thought it was only commercial stuff that interested the N. E. L. A."

Those are only two examples; we could cite others. And we agree with the A. S. M. E. Power Committee that by failing to furnish the operating engineer the important findings of engineering and technical organizations, power plant executives are handicapping him in achieving the highly intelligent operation of stations that is demanded by their great importance.

Power Plant Engineering has endeavored to assist in removing this handicap by publishing many of the important findings of the N. E. L. A. and the A. S. M. E. and we feel that the power plant operator should be aided by his own organization in securing information regarding the most important discoveries and operating methods and should be encouraged in this by his superiors.

Special Lighting

On the occasion of any celebration, special lighting is one of the first and foremost features to be planned. Light—plenty of light and colorful effects—are recognized as an important factor in achieving success. This was especially notable during the recent Christmas season but is there any reason why other festivals should fail to be similarly recognized by widespread illumination?

It is generally recognized in marketing centers that brilliant lighting makes for better business. Crowds are attracted and are put in holiday mood. The joy of living is increased and the community is benefited. In every city such illumination of business centers was to be seen last Christmas and, in many, the decorations of homes and private grounds were most attractive. One coördinated plan at Harrison, N. J., was especially remarked by travelers. The West Hudson Manufacturers' Association turned the ordinarily dark and somber industrial section into a colored fairyland. From the top of the Edison Lamp Works chimney, a 500-hp. jet of steam 200 ft. high was flood lighted into a waving rainbow plume, visible for miles and said by aviators to be a most effective wind indicator and land mark. The usual white lighting of signs was replaced and varied by red and green effects on the works of the Lamp Works, Worthington Pump and Machinery Corp., Otis Elevator Co., Hyatt Roller Bearing Co., Driver-Harris Co., and Crucible Steel Co. of America. Special light-

ing of water tanks, roofs and a large spray pond added to the effect.

While the maintenance of such effects continuously is hardly to be expected, special illumination in honor of national holidays such as Decoration Day, Fourth of July and Armistice Day can easily be accomplished when once the equipment has been acquired. Such extra load for central stations is even more desirable in the summer and fall than in winter when the usual lighting load is at its maximum.

Use of extra light for local gala occasions is growing and is worth while encouraging both for the added business to stations and the added joy to mankind. Why not many extra-illumination days throughout the year?

Off Duty

There seems to exist a prevailing belief that a speaking knowledge of several languages constitutes a mark of high education or even of high intelligence. The remark: "* * * he is a highly educated man—speaks five different languages" is heard so frequently that we have come, unthinkingly, to accept it.

Now, with no intention of presuming to criticize the study of languages, in the light of modern standards, a mere knowledge of even a dozen languages is neither a measure of a person's intelligence nor his education.

Education is understanding, not merely memory of terms, sounds or symbols, but understanding based on a knowledge of fundamental facts and sound logic. Education, in its broad sense, implies a knowledge of the world or universe we live in and this is not attained by a mere familiarity with certain spoken or written symbols.

Today, education implies, or should imply, an understanding of the sciences—of physics, chemistry, electricity and mathematics, for it is in terms of these fundamental sciences that our knowledge of the world is expressed. This applies not only to the material world but, in the author's opinion, to spiritual and cultural things as well.

It was not so long ago that so-called intelligent men waxed hot and furiously over discussions as to whether Archbishop Ushers' chronology as to the exact date of creation, based upon the addition of the ages of Adam, Enoch and Methuselah, was correct or not. Today, even among theologians, such discussions are considered absurd and despite the passage of anti-evolution laws in certain of our states, the age of the earth as interpreted by geologists is commonly accepted by the more intelligent of men and women.

So, also, our ideas of moral and spiritual values are being gaged by different standards. More and more, these are being measured in terms of nature's laws, rather than by the inflexible dogmatic rules handed down to us by bewhiskered ancients. The idea of a cruel, vengeful God is passing and in its place is growing a more rational conception of God or nature, call it what you will, that is consistent with known natural laws.

Not only is science capable of explaining material things and actions but it is beginning to explain what is meant by good and bad. No longer is a certain act good or bad because somebody has said so, but it is one or the other because science shows that it is the inevitable cause of an effect that concerns the world in one way or another.

To an increasing extent, therefore, education will demand a knowledge of scientific principles. Knowledge, in any sense, means simply an understanding of complex things in terms of simpler ones. Science has furthered human understanding by steadily reducing the number of simple terms until today we have at the root of all things and all action, only three entities—the two fundamental units of electricity, the positive and negative electron, and electromagnetic radiation.

So, in the future, any system of education that ignores even a more or less general consideration of the electron falls short of its purpose by an amount which will increase as time goes on.

In a survey recently made at an American college, it was shown that among all the students, only about five per cent of all the time spent during the college course was devoted to scientific subjects. This is an appallingly small proportion and accounts, no doubt, for the general lack of scientific knowledge. If one-quarter as much time were spent in acquainting the student with the simpler facts of modern science as is devoted to so-called cultural subjects, there might be more true culture among the populace than there is today.

In thus advocating greater attention to scientific studies, the author realizes that for the bulk of humanity, it is easier to accept dogma than it is to acquire, by process of logical deduction, an understanding of the true nature of things so that in this generation, at least, he fosters no expectation of any startling changes in human understanding. On the clock of geological time, civilization is but a minute old and perhaps we are expecting too much.

The progress of the human race has always been and, for a long time to come, will be in the hands of a few. These few, despite the inertia imparted by ignorance, prejudice and human passions, have slowly brought civilization to its present state. These few, too, are slowly growing larger and in the ages to come will be able to work more effectively.

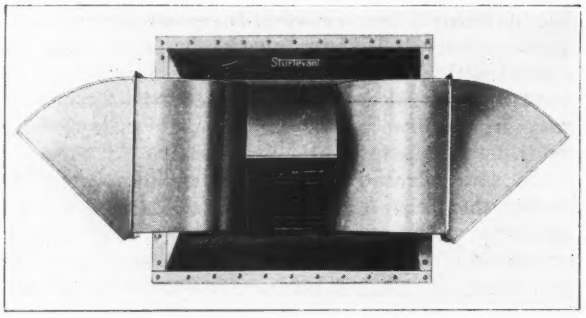
The hope of man on this earth need have no limits. Evolution is not finished. As J. Arthur Thompson put it recently, "In Darwin's day men had the vision of an evolved world; but now we are getting glimpses of a world evolving."

An Englishman by the name of Joule first determined the relation between the units of heat the B.t.u. and the unit of work or foot-pound. About 1850, he arranged a paddle wheel in a well-insulated can of water. The paddles were turned by weights which descended and unwound cords on the spindle of the wheel. The mechanical work input was found by multiplying the weights by the distance they fell, while the heat produced was measured by the rise in temperature of the water. Joule determined that about 778 ft.-lb. of work was equal to one B.t.u. Later and more accurate experiments have changed his result but little. These experiments of Joule did much to prove the then disputed principle of the conservation of energy, because it showed that heat and work are but different forms of energy.

Power Plant Engineering Developments and News

Sturtevant Tempervane Heating Units

TWO TYPES of Tempervane heating units have recently been placed on the market by B. F. Sturtevant Co., Hyde Park, Boston, Mass. One is the suspended type for use on walls or ceilings; the other is



TEMPERVANE SUSPENDED UNIT, SHOWING DIFFUSING CHAMBERS AND HEATING ELEMENT

a floor type unit designed to permit installation in narrow spaces between floor columns or against the walls. The accompanying illustration shows the suspended type unit.

High-pressure Aerofin heating elements, designed for steam pressures up to 350 lb. per sq. in., are used in these heaters. These elements consist of copper tubes on which a fin of copper ribbon is wound helically and soldered with high-melting-point solder. Trombone bend joints and special expansion plates are used.

Air is projected through the heating units by Sturtevant design 5 and 6 propeller fans. These are designed to be self-limiting in horsepower characteristics. They are driven by Sturtevant IMK totally-enclosed ball-bearing motors, made for standard phases of alternating current and designed with high starting torque.

Outlets of the Tempervane units are built for one to four-way discharge and are formed to permit a natural streamline flow around the bend and to project the air in any predetermined direction. They are directed to discharge towards the floor. With the suspended heaters, recirculating boxes are not recommended. Large diffusing chambers are provided between fan and heating section to permit uniform distribution of the air over the surface.

In the floor type heater, two propeller fans are mounted at the bottom of the unit on a removable tray to permit withdrawing the fan and motor for inspection. These fans blow the air through a diffusing chamber to the heating elements and it is discharged by chamber outlets in any desired direction.

Capacities of the suspended type units vary from about 1500 c.f.m., to about 8000 c.f.m. or from about 192,000 B.t.u. per hr. to about 1,200,000 B.t.u. per hr., depending on air and steam temperatures and fan speeds.

Floor heaters vary in capacity between about 3500 c.f.m. and 16,250 c.f.m. or from about 350,000 B.t.u. per hr. to about 2,180,000 B.t.u. per hr.

Sirocco Unit Heaters

SIROCCO unit heaters for industrial use have recently been developed for floor and ceiling applications and in high and low pressure types. As illustrated, the heater consists of a heating element in a casing

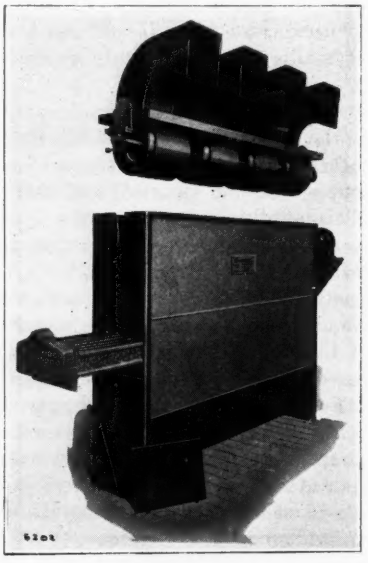


FIG. 1. SIROCCO UNIT HEATER, SHOWING FANS, HEATING ELEMENT, MIXING DAMPER

with several fans mounted on a common motor-driven shaft near the top, drawing air in at the bottom through a mixing damper, passing it over the heating coils and discharging it through cowls at the top. Figure 1 shows these component parts. When used as a ceiling type heater, the unit is turned on its side and straight cowls are used to discharge the heated air horizontally, as shown in Fig. 2.

Standard heating elements are of copper fin tubes expanded into one-piece cast-iron headers. For low

and medium steam pressure, four rows of tubes are ordinarily used; for high pressures, three rows usually suffice. Fans are double-width, double-inlet, multiple-blade Sirocco units mounted on brackets on a reënforced steel top panel as shown. This design is to permit the simultaneous removal of the entire battery of fans with shaft and bearings.

If desired, the heaters can be furnished with pipe coil heating elements of ¾-in. extra heavy steel pipe, welded into steam and drip headers, which are supported on a heavy structural steel frame.

Control of the unit can be by mercoid thermostat if desired. The new heater is supplied by American Blower Corp., Detroit, Mich., in various capacities,

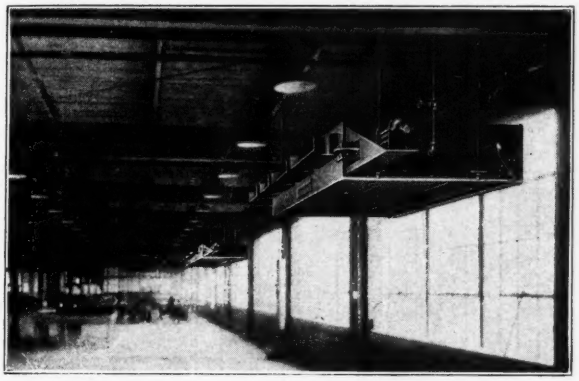


FIG. 2. SIROCCO UNIT HEATERS AS CEILING TYPE UNITS

varying, of course, with air and steam temperatures and fan speeds. These capacities vary from about 1200 c.f.m. to about 12,000 c.f.m. of air, depending on the conditions.

Massachusetts Modified Unit Heaters

MASSACHUSETTS modified unit heaters in new types for both floor and ceiling installation have recently been placed on the market. These include the Type V and the Type VF, both floor types and the Type H for ceiling use. The first two types are the same in construction, except that the Type VF includes air filter elements for cleaning the air.

These floor type units consist essentially of a casing, a heating element of standard type for steam pressures up to 75 lb. or of high pressure type for pressures up to 150 lb., two fans driven from one motor and, in the second case, air filter elements. Heating coils are of ¾-in. copper tubes, each wrapped with a thin copper radial fin in helical form, tinned to the tube and of proper width and pitch to give best heat transfer and maximum surface with minimum tube spacing. Tubes are expanded into cast-iron headers and are placed horizontally in the casing and properly drained and trapped.

Air is drawn in just above floor level by two fans of the backward-pitched, radial-flow type, mounted on extended shafts of a ball-bearing motor mounted on rubber pads, with automatic, push-button, across-the-line starting switches mounted on the side of the heater casing. Air is discharged through grilles at the top, at a point just above the breathing or working zone. In the type VF heater, air filter cells of standard design are inserted just above the fans and below the heating elements, as shown in Fig. 1. They are arranged so they can be easily withdrawn for cleaning. These floor type heaters are supplied in capacities from 3890 c.f.m. of air, corresponding to 1380 sq. ft. direct radiation, to

FIG. 1. TYPE V.F. UNIT HEATER, SHOWING HOW AIR FILTER CELLS ARE INSTALLED

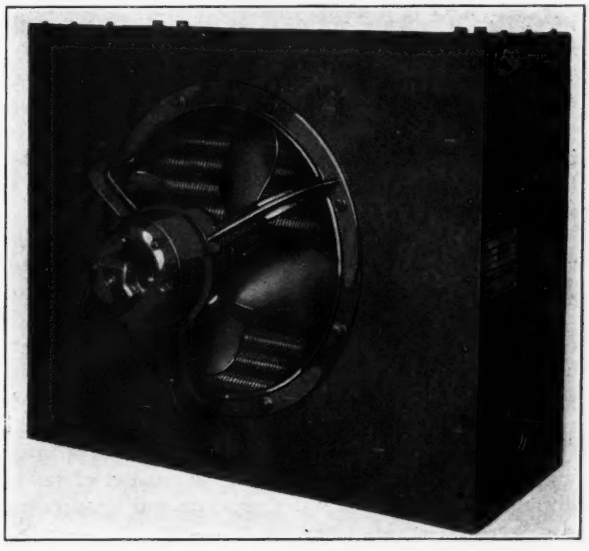


FIG. 2. TYPE H. UNIT HEATER

11,230 c.f.m. corresponding to 3272 sq. ft. radiation, depending, of course, on steam and air temperatures.

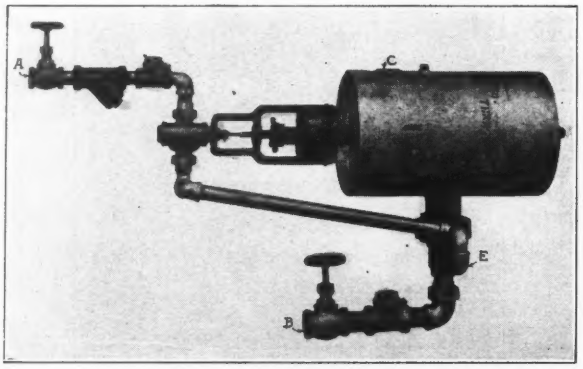
Type H heater, Fig. 2, consists of heater elements in a casing behind which is a propeller type motor driven fan. Motors are totally enclosed and automatically lubricated. These heaters can also be used as floor type units by equipping them with recirculating boxes, to lead the air from floor level up to the heater which discharges at the breathing zone. These Type H units are

designed in three sizes: 18, 24 and 30 in. with capacities ranging from 1750 c.f.m. of air to 6650 c.f.m.

The foregoing heaters are all products of Massachusetts Blower Division of Bishop & Babcock Sales Co., Cleveland, Ohio.

Sylphon Steam-Water Mixer

TO MEET demands for a flexible hot water supply system for industrial plants that would furnish water at the right temperature for a particular process and that could be located where the water is to be used, the Sylphon steam-water mixer has recently been developed by The Fulton Sylphon Co., Knoxville, Tenn.



REGULATOR CONTROLS STEAM TO MIXING VALVE TO GIVE PROPER WATER TEMPERATURE

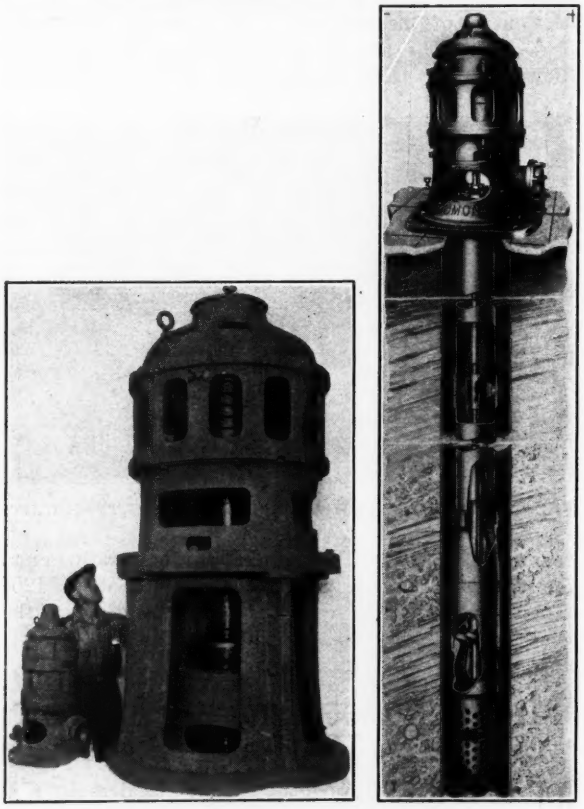
This device, as shown, consists of a temperature regulator, a mixing nozzle and an equalizing tank. Steam enters at A, passes through strainer and check valve to the temperature regulating valve and thence to the mixing valve E. Water enters through B, passes the check valve and goes to the mixing nozzle E, where it is mixed with the steam and heated. This hot water then passes into the equalizing tank and out at C through the pipe line to the point of use.

Amount of steam is controlled, of course, by the regulator, to give the hot water temperature desired. A simple handwheel adjustment is provided on the regulator for varying its setting. The mixing nozzle is designed to mix the steam and water with a minimum of noise, such as would not be objectionable in industrial plants. It is stated by its manufacturer that steam pressure must exceed water pressure by at least 15 lb. for good operation. Capacities of the apparatus range up to about 110 g.p.m., depending on amount of steam, difference in steam and water pressure and temperature rise necessary.

Large Vertical Pump Employs Water-Lubricated Bearings

FOR THE ETIWANDA, Calif., Water Co., the largest pump that has ever been constructed by The Pomona Pump Co. of Pomona, Calif., was recently installed and is in operation. The pump weighs 60,000 lb. and it is installed in a well 450 ft. deep and not only raises the water from this depth but boosts it an additional 190 ft., making a total head of 640 ft. The water is boosted to a hill where it is redistributed to lines and laterals for use in irrigating.

Lifting and boosting of the water is accomplished in one operation. A novel feature of the design is that the bearings are water lubricated. In the usual oil lubricated bearing, trouble is sometimes experienced from clogged oil lines, which may cause oil failure and bearing trouble; for this reason, this pump has been constructed to use the ever present water as a lubricant. Water containing sand causes rapid cutting of bearings but in this pump the bearings are of a resilient material that cannot be rapidly destroyed by sand. Furthermore, any sand that creeps into the bearings is washed out without permitting metal-to-metal contact that causes abrasion.



LEFT—NEW VERTICAL PUMP AT ETIWANDA FOR 640-FT. HEAD. RIGHT—WATER-LUBRICATED BEARINGS ARE USED IN THE PUMP ITSELF

The driving motor is a Westinghouse 350-hp., 50-cycle, 960-r.p.m., ball-bearing, vertical solid shaft unit.

Ljungstrom Air Preheaters of Improved Design

NEW FORM of heating element intended to increase heat transfer efficiency and still further reduce apparatus volume, weight and cost for given heat return, has been used in installations of the Ljungstrom Preheater for the past year and is now announced as a standard feature.

Modification from the design of heating element previously used is based upon the substitution of un-

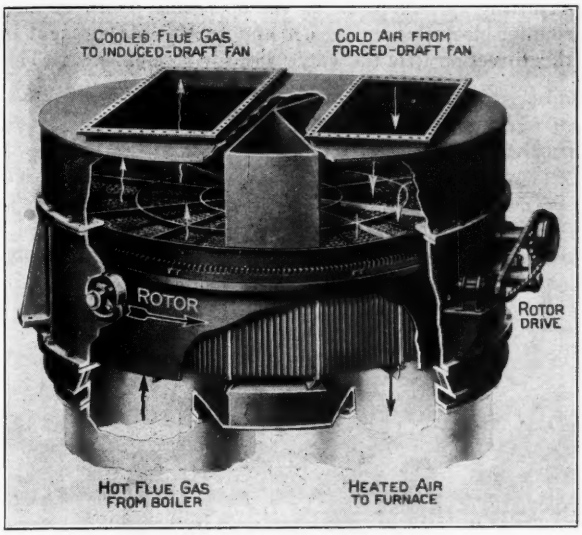


FIG. 1. PREHEATER FOR USE WITH SEPARATE FANS, SHOWING COMPACTNESS OF ARRANGEMENT

dulating partition sheets for the former flat partition sheets. The undulations are in transverse direction to the vertical channels formed by the corrugations of the companion sheets.

This new arrangement is intended to produce quick heat transfer because of the increased turbulence and wider penetration of flow, compelling the gas and air to strike against instead of merely pass over the metal surface. It is stated that a smaller volume of heating elements, which are shorter in length and have passages twice as large in cross-sectional area, will produce a given recovery. Use of these larger channels further materially reduces the draft losses through both gas and air sides at all velocities and, in connection with the turbulence, affords greater protection against fouling from soot. Fly ash and entrained carbon are more positively carried out of the preheater and the soot blower is more effective in dislodging any accumulation that does deposit.

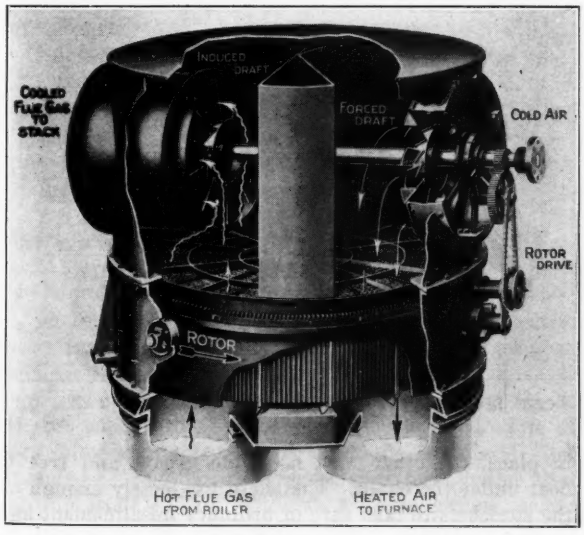


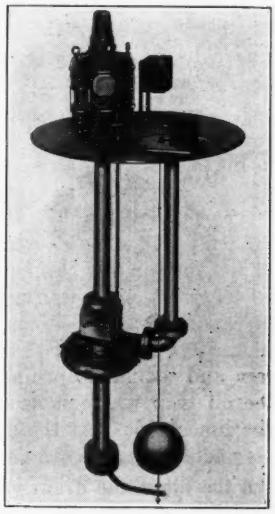
FIG. 2. NEW INTEGRAL FAN TYPE PREHEATER

Both the integral fan type preheater and the one formerly offered for independent fans (Fig. 1) now have shallower inlet and discharge chambers for both gas and air, giving less overall height for given capacity. Connections below the rotor of the integral fan type of preheater and all connections in the independent fan type may be located in the end or side of the housing. An additional independent fan type with all-vertical inlet and outlet connections is now offered. This type makes the ducts serve as inlet and outlet chambers and reduces the overall height to less than half that of the former design.

Literature illustrating and describing the new Ljungstrom air preheaters will be sent on application to the manufacturers, The Air Preheater Corp., 25 Broadway, New York.

American Sump Pumps

IMPROVED LINE of sump pumps has been announced by American Well Works, Aurora, Ill. The "American" type M. M. D. sump pump employs a hollow shaft motor in place of the solid-shaft type. This construction is intended to make possible a compact pump and to eliminate flexible couplings and thrust bearings. The pump shaft extends up through the motor shaft, hence both motor and pump use the same thrust bearing, which is mounted in the upper end of the motor.

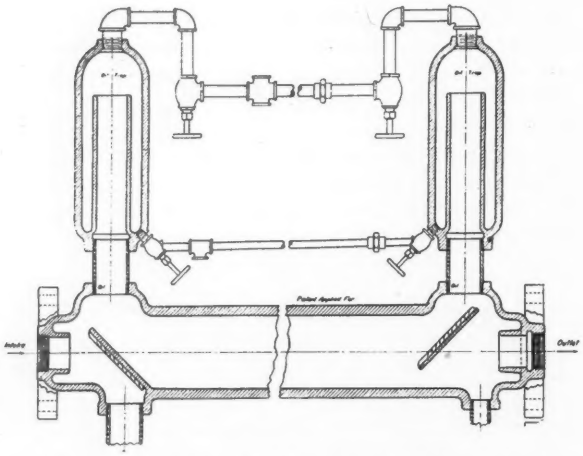


NEW SELF-CONTROLLED AMERICAN SUMP PUMP

Elimination of high motor supports is made possible, as the pump supporting pipe is bolted through to a cast iron plate that in turn bolts to the motor. Regardless of distortion in the pit cover, the alinement of the pump and motor is not affected. Pump shaft bearings consist of removable bushings. The pit plate is made of plate steel and is furnished either round or square. Pump may be had for all standard settings up to 17 ft. in either single or duplex units. All units are furnished complete with float control switch, oiling device and motor.

Bailey Feedwater Filter

OIL IN BOILER FEEDWATER has been known to cause much trouble in boilers and their accessories and many engineers are interested in methods designed to remove this oil. To do this, the Bailey feedwater



CROSS SECTION OF BAILEY FEEDWATER FILTER

filter has recently been placed on the market by Baker Valve Co., Minneapolis, Minn. It is intended for installation in the discharge line from the feed pump to the boiler.

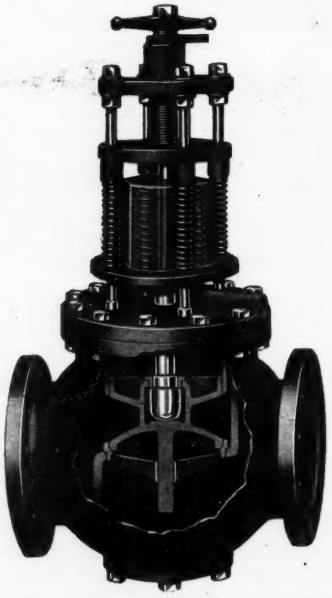
In operation, feedwater containing oil enters the intake, shown in the accompanying sketch, and strikes the cast iron baffle. Velocity of the water is reduced as it passes from the smaller entrance opening into the larger area of the filter itself; this velocity reduction, together with the change in direction produced by the baffle is intended to produce a centrifugal action and to separate the oil from the water. When this occurs, the heavier oil is intercepted by the baffles and is drawn off through the drain and sediment openings. The lighter oil rises into the oil trap where it accumulates in the space around the inner pipe. At the discharge end of the filter a similar action occurs.

To blow down the filter, the drain valves at the bottom of the trap are opened, going from inlet to discharge ends. After these are blown down, the valves on the lines from the top of the oil traps are opened and these are blown in the same order. Finally the sediment lines are blown down.

Turbine Exhaust Relief Valve

FOR THE PROTECTION of non-condensing turbine housings and low-pressure industrial systems, the spring-loaded relief valve shown here has been designed. It has a double set of springs, arranged so that the lift of the valve disc is evenly distributed between inner and outer springs to permit high lift with small compression of the springs.

Top area of the disc is specially balanced to destroy the effect of pressure on the outlet side. This construction, it is stated, allows greater flow of steam through a given size of valve and less building up of pressure for the full area of opening of the valve. Turning the adjusting spindle increases the operating point, turning counter-clockwise reduces it and further adjustment in this direction lifts the valve disc for free exhaust. This

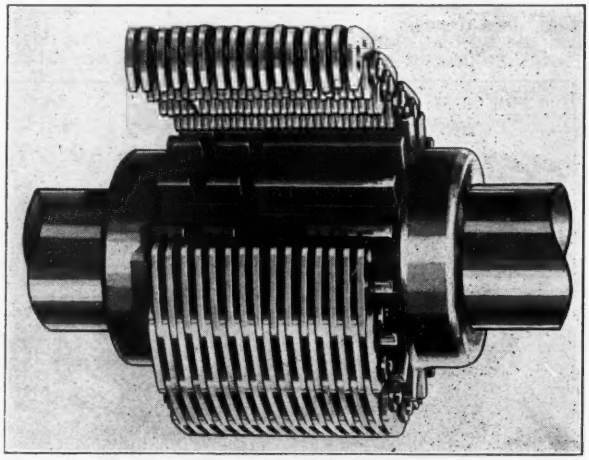


DOUBLE SPRING ARRANGEMENT DISTRIBUTES LIFT EVENLY

valve is supplied by its manufacturer, Ruggles-Klingemann Mfg. Co., Salem, Mass., in sizes from 4 to 24 in.

Flexible Coupling Employs Chain and Sprockets

FLEXIBLE COUPLING shown in the illustration consists primarily of a Morse chain wrapping two sprockets, each one-half the width of chain, one with a guide groove in the center of the face to hold the chain



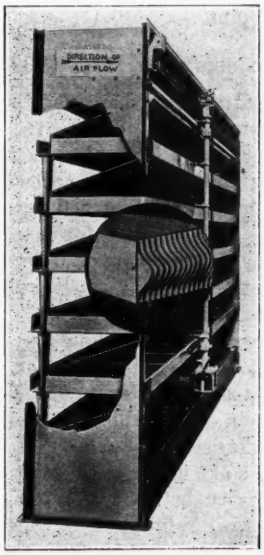
ONE SPROCKET FLOATS UNDER CHAIN TO TAKE UP MISALINEMENT

in place, the other with no guide groove and free to float under the chain. The chain fits loosely enough on the sprockets to take care of ordinary misalinement and lack of parallelism. The coupling is a recent product of the Morse Chain Co., Ithaca, N. Y.

Midwest Sinuous Air Filter

DESIGN of an air filter cell to direct and control the flow of air through the filter medium, thus decreasing air resistance and increasing capacity, has been the aim of Midwest Air Filters, Inc., Bradford, Pa., in developing its new sinuous air filter shown here. This is made in both vertical and horizontal types.

In the horizontal filter air enters at one side and is directed onto the horizontal filter medium, which consists of rows of sinuous baffles shaped as shown in the



INSERT SHOWS SHAPE OF AIR PASSAGES PRODUCED BY SINUOUS FILTER ELEMENTS AS USED IN THE HORIZONTAL TYPE

insert. Air enters between the rows, the entrance passage being straight to eliminate swirls and eddies in the entering air. The air then passes through the single curved passage, designed to cause the dust particles to be separated from the air by the centrifugal action and by the acceleration of air flow due to the venturi action of the passage. Combined and consecutive actions of retardation, bending and acceleration of the air stream are intended to be produced.

Surfaces of the sinuous elements are coated with viscous material to attract dust particles. This material is used to flush down the elements to clean them, when necessary, at the same time leaving on them a fresh coating; this process can be controlled automatically or by push button. The viscous material is fed through a header and a series of pipes reaching out over the elements and traveling across them. The viscous material flows down the baffle plates to troughs and thence to a cleaning trough at the bottom of the unit.

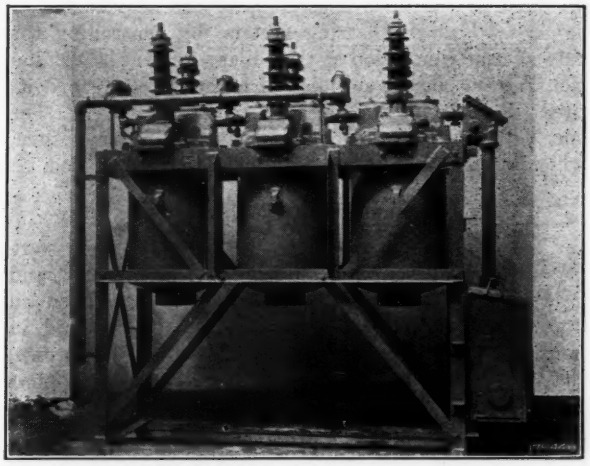
In the vertical type, the filtering medium is essentially the same, except that the cell plates are grouped vertically instead of horizontally.

Filters are made with elements 29 by 19⅝ by 3⅛ in. in size, each with a capacity of 3000 to 3500 c.f.m. of air. Maximum resistance through the horizontal filter is stated to be 0.34 in. of water and through the filter medium itself 0.25 in. The cells are arranged in various combinations to give air filtering capacities up to 240,000 c.f.m.

New Westinghouse Oil Circuit Breaker

ONE OF THE latest developments of the Westinghouse Electric and Manufacturing Co. is the new type oil circuit breaker illustrated here. This is known as the Type 0-30 oil circuit breaker, electrically operated, built for heavy duty service on alternating current lines and applicable to both indoor and outdoor service.

It is designed for 600, 1200 and 2000 amp. at 15,000 and 25,000 v. Several distinctive features have been embodied in the type 0-30 breaker, which assure reliable operation under the most severe conditions of service. The operating mechanism may be either the direct current, solenoid on motor-operated types mechanically full automatic in all positions of the breaker stroke. They are enclosed in a weatherproof, sheet steel housing, which is mounted on brackets on the breaker frame, thus lowering installation cost by eliminating the necessity



WESTINGHOUSE TYPE 0-30 OIL CIRCUIT BREAKER

of an extra mounting base and raising it out of the reach of water.

Substantial and rigid support for the pole units is provided by the welded steel, angle-iron framework. This construction permits inspection and adjustment of the contacts when the tanks are lowered.

At the point where the vertical pull rods from the mechanism connect with the horizontal pull rods along the top of the breaker, a double bell crank housing is provided. This housing is provided with a heavy partition separating it into two compartments; the pull rods from the operation mechanism enter one compartment and the pull rods to the pole units enter the other. Mechanical connection is made through the divided housing by a shaft-operated bell crank which eliminates the possibility of transfer of oil and gas from one pole unit to another or from pole unit to mechanical housing.

Each pole unit is equipped with a hydraulic bumper, thus eliminating rebound. A muffler eliminates oil throw and scavenging the gases. Busing-type current transformers with 5 different taps and 10 ratios can be furnished if desired.

A.S.H.&V.E. Speakers Report Progress in Many Lines at 35th Annual Meeting

MANY PHASES of heating and ventilating engineering were treated in a comprehensive program of papers presented before the American Society of Heating and Ventilating Engineers at its 35th Annual Meeting held at the Edgewater Beach Hotel, January 28-31, 1929.

On Monday afternoon, C. A. Thinn presented a paper on Heating with Steam below Atmospheric Pressure. To do this, a system is used that is a development of the vacuum return-line system. Its object is to obtain flexibility in heat output to meet variations in weather conditions while maintaining uniform room temperature, the steam being circulated in the piping under a positive differential sufficient to cause flow through the radiating surfaces. For small installations, steam is supplied at the same absolute pressure at which it is to be used in the heating system, by controlling the rate of heat generation at the boiler; for larger installations, steam may be supplied at higher pressure and its pressure lowered by pressure reducing valves. The speaker described the equipment used in the system, which may be manually or automatically controlled.

Effect of Painting Radiators

Experiments on the Effect of Surface Paints were reported on Tuesday morning by C. H. Fessenden and Axel Marin of Ann Arbor. Tests were conducted on two modern radiators of the type ordinarily used in house heating, using five paints: aluminum, flat brown, flat-tone cream, liquid gold and vitralite, a white-gloss enamel. One of the radiators was left unpainted for a standard and the paints were applied to the other, both being kept at the same conditions for each test. The tests were started with a bare radiator, relative heat emission being assumed 100. Then, on application of a single coat of aluminum paint it dropped to 92.0. A coat of gold bronze was applied over the aluminum and the rate was 90.2 and 93.5. A coat of flat tone cream was added and the emission rose to 104.9, another coat of aluminum caused it to drop to 95.3, 94.7 and 93.7. A coat of brown gave an emission of 104.7 and a final coat of white enamel on the brown gave 103.6. Check tests were then run. It was concluded that only the final coat affects the heat emission.

Radiator Enclosures and Concealed Heaters

Investigation of Heating Rooms with Direct Steam Radiators equipped with Enclosures and Shields was presented by A. C. Willard, A. P. Kratz, M. K. Fahnestock and S. Konzo. In general, the tests showed that, when properly designed, metal enclosures enable the radiator to give proper temperature at the breathing zone, lower temperature at the ceiling, lower condensation and, in general, better room conditions. Tests of a cloth cover showed it to be unsatisfactory. The form of enclosure giving best results, was found to be one with the greatest free area of opening allowing unrestricted air flow.

In a paper on Architectural Aspects of Concealed Heaters, the heating effect was shown to be similar to that in the foregoing paper and the authors, J. H. Milliken and H. C. Murphy, discussed methods of installing and applying concealed radiation from the architect's viewpoint.

Coefficients of Heat Transfer

On Tuesday afternoon, the general subject was heat transfer. Thermal Resistance of Air Spaces, a paper by F. B. Rowley and P. B. Algren, described experiments along this line using air spaces between various commercial insulating materials. They showed that air space coefficients are the same for many materials and that undoubtedly materials used in building construction can be classified into a small number of groups, with characteristics for each group.

Another paper by F. C. Houghten, Carl Gutberlet and C. G. F. Zobel described further experiments on Coefficients of Heat Transfer under Natural Weather Conditions. Their data verified in most cases the computed values contained in the A. S. H. & V. E. guide; concrete was the only material showing a marked variation in conductivity between measured and computed values. Tests of air infiltration through various types of brick walls were reported by G. L. Larson, C. Braatz and D. W. Nelson.

At the Wednesday morning session, a paper on Heat and Moisture Loss from the Human Body and Its Relation to Air Conditioning was presented by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant. Cooling and Humidifying of Buildings was presented by S. C. Bloom and The Summer Comfort Zone: Climate and Clothing by C. P. Yaglou and Philip Drinker. M. C. W. Tomlinson presented a paper on Low Humidity Psychrometric Charts.

On Wednesday afternoon, L. W. Leonhard and J. A. Grant analyzed the formation of frost and condensation on windows. They showed that double glazing with air space between would prevent this, although it is expensive and difficult to construct. Another way, in dwelling houses, is to air the entire house for two or three minutes at intervals of two or three hours, thus allowing the outside air to change the humidity. Circulation of air by a fan is also effective.

Report of the Committee on Rating Low-Pressure Heating Boilers was made by its chairman, Alfred Kellogg.

On Thursday morning, there was discussion on correlating thermal research, a report of the committee on heating and ventilating garages, a paper by J. H. McIlvaine on Application of Oil Burners to Various Types of Domestic Heating Systems and a paper by H. C. Russell on Laundry Kitchen and Hospital Equipment.

Fan Performance

At the last session on Thursday, G. E. McElroy delivered a paper on Ratio of Opening of Fan Perform-

ance in Terms of Direct Pressure-Quantity Relations. The writer investigated mine fans for which average data were in the form of ratio charts in which performance ratio is plotted against ratio of opening. The latter is the ratio that the area of an orifice in the discharge end of a short test duct bears to the area of the duct, which is made the same as that of the fan discharge. His work necessitated the determination of losses in thick-plate, square edged orifices.

In attempting to correlate ratio of opening used as a basis for expressing relative fan performance, the author has analyzed the results of pressure-loss experiments on orifices, with particular reference to the thick-plate, square-edged type involved in fan test work, and has found that, within practical limits of application, a single constant can be used to define a type of orifice. The constant referred to is the ratio of static pressure at the orifice, when discharging into the atmosphere, to the difference in velocity pressures between the duct area and the orifice area. The use of this constant is proposed as a method of fairing-up experimentally determined coefficients of discharge for orifices.

The constant derived from experiments on thick-plate, square-edged orifices, 2.45, has been used in calculating values of ratios of opening, and velocity-pressure ratios, in terms of direct pressure-quantity relations. This involves a new conception—termed "resistance constant"—for the expression of pressure-quantity-area relations and one that seems particularly adapted for use as a basic scale in presenting data on relative fan performance. A chart, based on this new conception, is presented for the rapid graphical determination of ratio of orifice, and velocity-pressure ratios from direct pressure-quantity relations.

Officers of the society elected for the ensuing year are: Thornton Lewis, president; L. A. Harding, first vice-president; W. H. Carrier, second vice-president; W. E. Gillham, treasurer.

Westinghouse Elects Robertson Chairman of Board

ANDREW WELLS ROBERTSON of Pittsburgh, president of the Philadelphia Co., was unanimously elected chairman of the board of directors of the Westinghouse

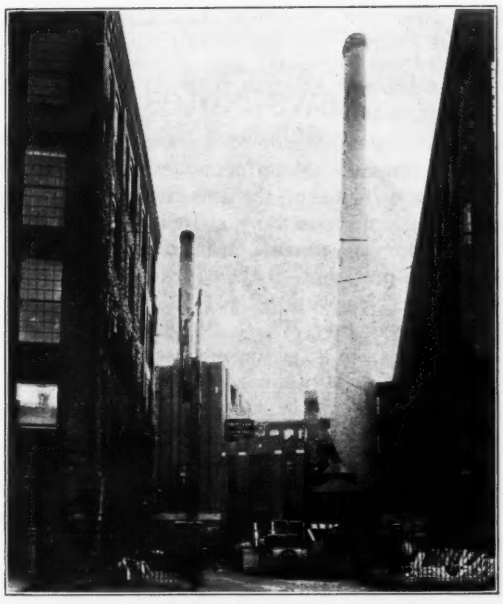
Electric & Manufacturing Co. in a meeting of that board, held in its offices at 150 Broadway, New York City, on January 16.

Mr. Robertson is 49 years old, was graduated from Allegheny College, Meadville, Pa., in 1906 with a degree of AB and from the Law School of the University of Pittsburgh in 1910 with a degree of LLD. After practicing law in Pittsburgh, he became general attorney of the Philadelphia Co., which, with its affiliated companies operated all of the electric light and street railway properties and most of the gas properties in the Pittsburgh district. After having served for several years as vice-president of that company in charge of public relations and the Law Department he was elected as its president in 1926, which office he has held since.

Mr. Robertson will withdraw from his other business activities and devote his entire time to the Westinghouse Co. For the present his official headquarters will be in Pittsburgh.

Underwood-Elliott-Fisher Co. Builds New Boiler Plant

AT THE HARTFORD, CONN. plant the Underwood-Elliott-Fisher Co. is building a new boiler plant which is scheduled for operation in June, 1929. Three 607-hp. Stirling boilers with Bernitz furnace



NEW UNDERWOOD-ELLIOTT-FISHER CO. POWER PLANT UNDER CONSTRUCTION

blocks, Riley forced draft stokers, Craig damper regulators, Stets feedwater control and Diamond soot blowers are being installed in practically the same location as the old boiler plant which had to be kept in operation while construction was going on. One of the old return tubular boilers will be reset as a rubbish burner.

The new Custodis chimney, 200 ft. high, 9 ft. 6 in. in diameter at the top and 20 ft. 6 in. at the bottom, is built of matched Clearfield, New Jersey, brick. Stephens-Adamson coal conveying equipment delivers coal to the 900-t. bunkers which feed by gravity to the stoker hoppers. Ash will be elevated by a skip hoist to the 1500-cu. ft. ash hopper shown at base of stack.

Lockwood, Green Engineers, Inc., are handling the engineering work. H. L. Crosby is resident engineer. Aberthaw Co. is the general contractor.

Death of Charles A. Daniel

CHARLES A. DANIEL, president of the Quaker City Rubber Co. located at Wissinoming, Phila., died at his home, 1520 Spruce St., Philadelphia, on Monday, December 24, after a brief illness. Mr. Daniel spent most of his life in Philadelphia. After being graduated from the Philadelphia College of Pharmacy, he entered upon a pharmaceutical career but in a short time felt that the rubber industry offered a wider field of activity. Later, he established the Quaker City Rubber Co. He was successful in originating and marketing a number of rubber specialties.

Up to the time of his death, he was a director of the Fourth Street National Bank, now the Philadelphia National Bank. He was among the original trustees appointed to develop the work of the Philadelphia Commercial Museum and was also a member of the Philadelphia Chamber of Commerce, the Pennsylvania Chamber of Commerce, the National Chamber of Commerce and the International Chamber of Commerce.

Mr. Daniel was a member of the Pennsylvania Society of the Sons of the American Revolution, the Union League, the Manufacturers' Club, Union Lodge No. 121, Free and Accepted Masons and Corinthian Royal Arch Chapter No. 250, all of Philadelphia.

News Notes

ANNOUNCEMENT is made of a change in the name of the Cutler-Hammer Manufacturing Co., Milwaukee, Wis. The new name of the company will be Cutler-Hammer, Inc., organized as a Delaware corporation, with the following officers: Chairman of the board, F. R. Bacon; president, B. L. Worden; vice-president, F. L. Pierce; vice-president, J. C. Wilson; treasurer, H. F. Vogt; secretary, W. C. Stevens. In the change from a Wisconsin to a Delaware corporation, the Cutler-Hammer Mfg. Co., Milwaukee, the Cream City Foundry Co., Milwaukee and Cutler-Hammer Manufacturing Co., New York, are united under one name.

ELLISON DRAFT GAGE CO., Chicago, Ill., announces that Walter T. Ritter, formerly of the Burke Engineering Co., has joined its organization as sales manager, located in the main office at 214 West Kinzie St., Chicago.

MIDWEST PIPING & SUPPLY CO., INC., St. Louis, Mo., announces the appointment of E. A. Kerbey as its Chicago manager with offices at 208 S. La Salle St., Chicago, Ill. Mr. Kerbey is a graduate mechanical engineer from the University of Michigan and for the past 3½ yr. has been with D. H. Skeen & Co., Chicago. Previous to that time he was employed by Western Electric Co., American Well Works, and Payne-Dean, Limited.

REITER CO., Elgin, Ill., announces a change in corporate name as of January 15, to Elgin Water Softener Corp. The management and officers remain the same and the trade mark of the company will be unchanged.

BIDS will be opened, Feb. 18, for a new electric generator of either 1500 or 2000 kw. capacity for the municipal electric plant at Ames, Iowa. Bids upon both generators will be received at that time and decision made then upon the installation. Complete improvements will cost $53,800, it is estimated by Henry P. Ames, city manager, who urged immediate increase of the plant capacity to meet constantly increasing service demands. The three units now in use are barely able to meet peak requirements and when the large single unit is in operation, these smaller capacity generators will become standby equipment.

ANHEUSER-BUSCH, INC., has authorized an expenditure of $1,000,000 for a new power plant to be erected at its main works, St. Louis, Mo., according to a recent statement by August A. Busch, president of the company. Work on the foundation of the plant, which will be centrally located near 9th and Pestalozzi Streets in one of the main buildings in the Anheuser-Busch group, has been under way for two months and is now completed. The inside walls of the building which will house the new power plant, have been completely rebuilt and preparations for the erection of the new machinery are now under way.

This new installation will have three 1100-hp. Springfield boilers which generate steam at a pressure of 500 lb. and a temperature of 600 deg. F. Two Allis-Chalmers 3750-kv-a. turbine generators will make all power required by the entire plant. The turbines are so designed that all steam which has passed through them to generate power is subsequently used for manufacturing purposes, so that complete use is made of every pound of steam. The new boilers will be fired with powdered coal. Capacity of two boilers will be sufficient to meet the company's maximum steam requirements which are about 200,000 lb. of steam an hour. According to Mr. Busch, the new power plant will cut the company's steam cost in half and the cost of generating power through use of the new turbo-generators will be approximately 20 per cent of the present power generating cost. It is expected that an annual saving of $100,000 in boiler and power plant labor alone will be effected through the economical operation possible with the new equipment. The new equipment is designed not only to meet the present requirements of Anheuser-Busch organization but to take care of expected changes in production and general plant operation for a number of years to come. The plant, according to present plans, will be completed in the early part of 1930. Ophuls & Hill, Inc., of New York City is the consulting engineer.

G. T. SHOEMAKER, electrical and mechanical engineer of the United Light & Power Co., has announced that A. S. Bisbee will be superintendent of construction on the Riverside power plant addition at Bettendorf, Iowa, which will cost $1,400,000. Mr. Bisbee was in charge of the United Light building in Davenport, Iowa, and the new service building recently erected in Lincoln, Nebr., and has had charge of various other larger projects of the utilities company. Mr. Shoemaker and his staff will have general supervision of the work.

YARNALL-WARING CO., Chestnut Hill, Philadelphia, Pa., is sending out a novel and interesting model which shows in direct action the operation of the Yarway Floatless Hi-Lo alarm water column and Se-Sure inclined water gage. A celluloid sheet, representing the water level, works up and down to show exactly what happens in both the water gage and the water column as the water level rises and falls. It also shows the action of the alarm whistle when the water level becomes either too high or too low for reasonable operation. With the model is a description sheet showing how it operates

and calling attention to the actions which take place during operation. This ingenious and interesting device can be obtained from the company at its Philadelphia address.

Pacific Gas & Electric Co. has applied to the California Railroad Commission for authority to begin construction of a hydroelectric development on the North Fork of the Mokelumne River and its tributaries. It is the applicant's plant to construct a chain of four or more hydroelectric plants having a total installed capacity of about 147,000 kv-a. and an annual estimated output of 814,000,000 kw-hr.

Books and Catalogs

Mechanical Power Transmission, by William Staniar, McGraw-Hill Book Co., New York City; 409 pages, 326 illustrations, 58 tables; 6 by 9 in., cloth, 1928; price, $5.

Practical information, based upon operating facts and experiences of one who has had years of experience and specialization in all phases of mechanical power transmission in the numerous plants of two of the largest manufacturing corporations of the world, is compiled and arranged into useful, non-technical, working form especially designed for use by the master mechanic and millwright. It will also be found useful to the plant engineer and draftsman.

Only simple formulas are used and all explanations are so clear and well arranged as to be of help to anyone who must apply transmission data to solve his everyday problems. An ample index enhances the availability of the book.

Selection and operation of equipment and materials needed in mechanical power transmission are ably treated under the following main heads; various types of belting, pulleys, short center driving methods, shafting, power transmission appurtenances, bearings, clutches, couplings, rope transmission, variable speed mechanisms, chain transmission, gear reduction units, lubrication of power transmission equipment and accident prevention. Conventional details and arrangements, special designs and commercial equipment are given quite complete treatment under these various headings.

Elliott induction motors, 20 to 200-hp., 2 or 3-phase, 40 deg. C. for continuous duty, are described in bulletin L-1 by Elliott Co., Pittsburgh, Pa. Bulletin J-1 describes Elliott engine-type, commutating-pole generators, type K., while bulletin AA describes twin oil strainers for Diesel engine injection valves, oil burner nozzles, lubricating systems and the like.

Wagner distribution transformers are described with tables of dimensions and capacities in a fifty-two-page bulletin No. 160, by Wagner Electric Corp., St. Louis, Mo.

Chrome refractories in the boiler furnace are discussed in bulletin 10-3-A by E. J. Lavino and Co., Bullitt Bldg., Philadelphia, Pa.

"Dracco and some Grinding Problems" is the title of a bulletin describing solution of the problem of grinding charred bones to produce Bone Black. It is published by the Dust Recovering & Conveying Co., Harvard Ave. and East 116th Sts., Cleveland, Ohio. Another bulletin, issued by the company, describes the use of pneumatic conveyors in a large mining and smelting company to handle poisonous dust.

Seymour-carbofrax furnace is described with details of its application in a recent bulletin of the Carborundum Co., Niagara Falls, N. Y., and Erie City Iron Works, Erie, Pa. Another bulletin describes the application of powdered coal by the Erie City Iron Works to return tubular boilers.

Mettler entrained combustion gas burners are described, with many illustrations of their applications to boilers, in a twenty-four-page booklet sent out by Lee B. Mettler Co., 406 So. Main St., Los Angeles, Cal.

Anderson Type K oil engines for any stationary power purpose, 30 to 325 hp., are described in detail with many illustrations of the parts in an eight-page bulletin, 32-K, sent out by Anderson Engine & Foundry Co., Anderson, Ind.

The Penroi Pumper, a compact, large-capacity, portable pumping unit, as described in a recent bulletin, is designed for unwatering excavations, coffer-dams, trenches, subways, conduits, and similar work. The pump is of single suction, open impeller type, with 3-in. discharge and 4-in. suction openings and is driven by a Le Roi, two-cylinder, 8-hp., radiator-cooled gasoline engine. Bulletin No. 213 contains detailed information about the unit and is issued by the Pennsylvania Pump and Compressor Co., Easton, Pa.

Water testing equipment for laboratory and power plant use is described in a recent bulletin by National Aluminate Corp., 6216 West 66th Place, Chicago, Ill. The bulletin also includes directions for testing water.

New O-331 oil circuit breakers are described in circular C-1803, a recent publication of Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. These circuit breakers are for indoor and outdoor service, are electrically operated and are rated at 600, 1200 and 2000 amp., 25,000 v.

Large polyphase induction motors, 5000 hp., 6600 v., 595-r.p.m. steel-mill type, are described in bulletin 1087-F by Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

McClave grates, stokers and steam blowers are described in a collection of loose-leaf bulletins bound in a cover, issued by McClave-Brooks Co., Scranton, Pa. Chain grate stokers for bituminous coal, with natural or forced draft, and various types of hand stokers and anthracite stokers are described.

Bigelow-Hornsby water tube boilers are described in a series of attractively illustrated bulletins, bound in a cardboard cover and issued by the Bigelow Co., New Haven, Conn. Details of the boilers and views of actual installations are shown, together with details of the Bigelow water wall surface and slag screen for furnaces.

New direct-connected gas-engine-driven compressor, type XG, is illustrated and described in a recent bulletin, No. 3149, issued by Ingersoll-Rand Co., 11 Broadway, New York City. The machine consists of a two-cylinder, four-cycle gas engine, direct-connected to Ingersoll-Rand compressing cylinders with plate-type valves.

Power Plant Construction News

Ala., Tuscumbia—The National Lime, Cement & By-Products Corporation, Mutual Building, Buffalo, N. Y., will install power equipment in proposed lime and lime products manufacturing plant on tract of land acquired near Tuscumbia, entire project to cost more than $250,000. F. L. Hoff is president.

Ark., Morrillton—The Coca-Cola Co., Atlanta, Ga., plans installation of power equipment in proposed new bottling plant at Morrillton, entire project to cost close to $80,000.

Calif., Antioch—The Fibreboard Products Co., San Francisco, plans installation of power equipment in proposed two-story plant unit at Antioch to cost approximately $100,000.

Calif., San Diego—The San Diego Consolidated Gas & Electric Co. is arranging for a stock issue to total close to $3,000,000, the majority of proceeds to be used for an expansion and improvement program in generating plants and transmission lines.

Colo., Alamosa—The Marion Mining Co., Alamosa, has made application for permission to construct and operate a hydroelectric power plant on the Alamosa River in Rio Grande County, divided into two generating plant units on different sites. Project will include a transmission line. Estimated cost not announced.

Conn., Hartford—The Arrow Electric Co., Hawthorn Street, plans installation of power equipment in proposed two-story addition to electric equipment manufacturing plant, entire project to cost in excess of $100,000. Mylchreest & Reynolds, 238 Palm Street, Hartford, are consulting engineers.

Fla., Tampa—The Asiatic Petroleum Co., Ltd., 65 Broadway, New York, N. Y., is said to be planning construction of new power plant in connection with an expansion program at its refinery and distributing plant at Tampa, entire project to cost more than $200,000.

Idaho, Coolin—The Pacific States Pulp & Paper Co., Aberdeen, Wash., plans installation of power equipment in proposed new mill on site acquired on the Priest River, near Coolin, entire project to cost in excess of $500,000, with machinery.

Ill., Chicago—The Athletic Shoe Co., 934 North Marshfield Street, plans installation of power equipment in proposed two-story addition to cost more than $100,000. R. C. Harris, 190 North State Street, is architect.

Ill., De Kalb—The DeKalb Sanitary District, DeKalb, S. M. Hunt, secretary, is planning call for bids early in March for pumping and other machinery for a proposed sewerage purification and treatment plant, estimated to cost about $125,000. W. M. Hay, Leslie Block, is consulting engineer; Suhr, Berryman, Peterson & Suhr, 130 North LaSalle Street, Chicago, Ill., are consulting engineers.

Iowa, Marshalltown—The Marshalltown Canning Co., South Second Street, plans installation of power equipment in proposed new two-story addition to factory reported to cost $150,000. McMeans & Tripp, 591 Middle Drive, Indianapolis, Ind., are consulting engineers.

Kan., Wichita—The Knowl Aircraft Corporation, 471 West First Street, will install power equipment in proposed aircraft plant to cost close to $100,000, for which plans are being completed. T. N. Thomas is president.

Ky., Ashland—The Ashland Refining Co. plans installation of power equipment in connection with proposed rebuilding of oil refinery at Leach Station, destroyed by fire, Jan. 16, with loss estimated at close to $135,000.

Md., Baltimore—The Board of Trustees, University of Maryland, Baltimore, is having plans drawn for a new central power house for heating service at the institution to cost approximately $175,000, with equipment. Smith & May, Calvert Building, are architects.

Mass., Uxbridge—The Stanley Woolen Co., Uxbridge, plans installation of power equipment in a proposed five-story mill addition, entire project reported to cost more than $100,000. It is understood that work will begin during the summer. Stanley H. Wheelock is president.

Miss., Bruce—The Eupora Ice Co., Eupora, Miss., has acquired property at Bruce and contemplates early construction of new ice-manufacturing plant, reported to cost more than $30,000. J. B. Johnston heads the company.

Neb., Grand Island—The City Council, Grand Island, is completing plans for extensions and improvements in municipal power plant, reported to cost about $30,000, with equipment. A. D. Baker, Clinic Building, Grand Island, is architect and engineer.

N. H., Laconia—Scott & Williams, Inc., Laconia, plan installation of power equipment in proposed new addition to knitting machinery manufacturing plant, entire project reported to cost more than $100,000.

N. J., Bayonne—H. Aronsohn, Inc., Avenue A and Twenty-third Street, plans installation of power equipment in connection with proposed rebuilding of portion of three-story silk mill, destroyed by fire, Feb. 1, with total loss estimated in excess of $175,000.

N. Y., Buffalo—The New York Central Railroad Co., 466 Lexington Avenue, New York, has filed plans for new coach repair shops at East Buffalo, project to cost about $200,000.

N. Y., New York—The Board of Education, Hunter College, Park Avenue and Sixty-ninth Street, plans construction of new power plant at institution in connection with expansion program to cost about $750,000. Thompson, Holmes & Converse, 101 Park Avenue, New York, are architects; Kaiser, Muller & Davis, same address, are electrical engineers.

Ohio, Dayton—The National Cash Register Co. will install power equipment in a proposed six-story addition to plant, entire project reported to cost more than $150,000.

Ohio, Cleveland—The Otis Steel Co., Jennings Road, plans installation of power equipment in connection with a plant expansion program reported to cost more than $300,000.

Ohio, Toronto—The Toronto Paper Mfg. Co., Loretta Avenue, plans the installation of power equipment in connection with an expansion program at its mill to cost close to $100,000. James H. Cayford is vice-president.

Okla., Oklahoma City—The Oklahoma Structural Steel Co., Oklahoma City, plans construction of one-story steam power house in connection with proposed steel fabricating plant, for which tract of 15 acres of land has been acquired. Will install power equipment for works service. Entire project is reported to cost more than $350,000.

Pa., Rouseville—The Rouseville Cooperage Co., Rouseville, plans installation of power equipment in connection with proposed rebuilding of barrel and stave plant recently destroyed by fire with loss estimated in excess of $125,000. It is understood that a new boiler house will be built.

Texas, Pecos—The Ozark Chemical Co., Ritz Building, Tulsa, Okla., plans installation of power equipment in proposed new sulphuric acid plant near Pecos to cost approximately $200,000. A boiler house is proposed.

Texas, Sulphur Springs—Burnett, White & Co., Sulphur Springs, have plans under way for construction of one-story ice-manufacturing plant with initial capacity of 15 tons per day, reported to cost close to $34,000, with equipment.

Utah, Hyrum City—The City Council has made application for permission to construct and operate a municipal hydroelectric power plant on the Blacksmith Fork River, with initial capacity of about 600 hp., to be increased at later date. Installation will include diversion dam, penstock and generating station.

Wis., Prairie du Chien—The Prairie du Chien Woolen Mill Co. will make extensions and improvements in boiler plant and power system, including installation of additional equipment. Charles A. Cahill & Sons, 214 Mason Street, Milwaukee, Wis., are engineers.

Wis., Sheboygan—The Phoenix Chair Co., Twelfth Street and Virginia Avenue, is completing plans for the complete electrification of its factory and will install new power equipment. Charles A. Cahill & Sons, 214 Mason Street, Milwaukee, Wis., are engineers.

Wis., Stoughton—The City Council has authorized plans for the construction of an auxiliary steam-operated electric power plant for municipal service reported to cost about $35,000. E. E. Dillon and J. M. Murphy, 7 South Pinckney Street, Madison, Wis., are engineers.